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Abstract | The challenges associated with investigating serious crime, particularly organised crime, are well known. Increasingly, police are turning to new information technologies to support traditional investigative techniques.

Automated ballistic information technology allows police to link cases that would otherwise not be known to be related. By linking investigations, police can identify new leads and suspects.

The current study used interviews with investigators in two states to understand what impact ballistic evidence has on criminal investigations into firearm crime. The results revealed a significant number of cases benefited from linked investigations—including cold cases and cases involving organised crime groups.

This research helps to demonstrate the potential value of technology to law enforcement, and the circumstances in which it is most effective.

Impact of ballistic evidence on criminal investigations

Anthony Morgan and Penny Jorna

There has been a long-term downward trend in firearm-related homicides and non-fatal shootings in Australia (Bryant & Cussen 2015; Fitzgerald 2013). However, firearms are still used in around one in six homicide incidents (16%; Bryant & Cussen 2015), and there have been spikes in drive-by and non-fatal shootings, concentrated in a relatively small number of New South Wales (NSW) communities (Bureau of Crime Statistics and Research 2015; Fitzgerald 2013). These incidents attract significant media interest and contribute to community concern about the involvement of firearms in crime. Further, while firearms may be less commonly used in crime than other weapons, there is evidence that they increase the risk of lethal injury (Mouzos 2003).

Research based on data on seized firearms has demonstrated a high concentration of firearms among serious and organised crime groups (Bricknell 2012). Firearms are used by organised crime groups as part of territorial disputes, to obtain protection money, to promote their image and reputation and for conflict or revenge purposes (ACIC 2016). According to research by the NSW Bureau of Crime Statistics and Research (BOCSAR), at least one-third of 'shoot with intent' and 'discharge firearm into premises' incidents are related to gangs, drugs or organised crime, while this information was unknown in nearly half of all incidents (Fitzgerald 2013).

This can pose significant challenges for the investigation of firearm-related crime by police. In many incidents of non-fatal shootings, victims and offenders are known to one another and have a criminal relationship, which means that victims are often unwilling to cooperate with police, even when they have been shot by the offender (BOCSAR 2015). Mouzos and Muller (2001) found that unsolved homicides were significantly more likely than resolved cases to involve a firearm. Similarly, Canadian research has shown that homicides involving firearms are three times more likely to be unsolved when compared to homicides involving other weapon types, and the involvement of other criminal activities (eg gangs, drugs) significantly increases the likelihood a homicide will remain unsolved (Dauvergne & Li 2006). Further, simply increasing the amount of resources given to an investigation has been found to have a limited impact on whether or not a case will be solved (Worrall 2016).

Police have therefore looked to new methods to aid in criminal investigations into firearm crimes as part of a wider trend towards the use of technology in law enforcement (Koper, Lum & Willis 2014). Some of these technologies—such as closed-circuit television, body-worn videos and DNA evidence—have been subjected to more empirical study than others. This paper examines the impact of ballistic evidence, obtained through a national automated ballistic information network, on criminal investigations into firearm crime.

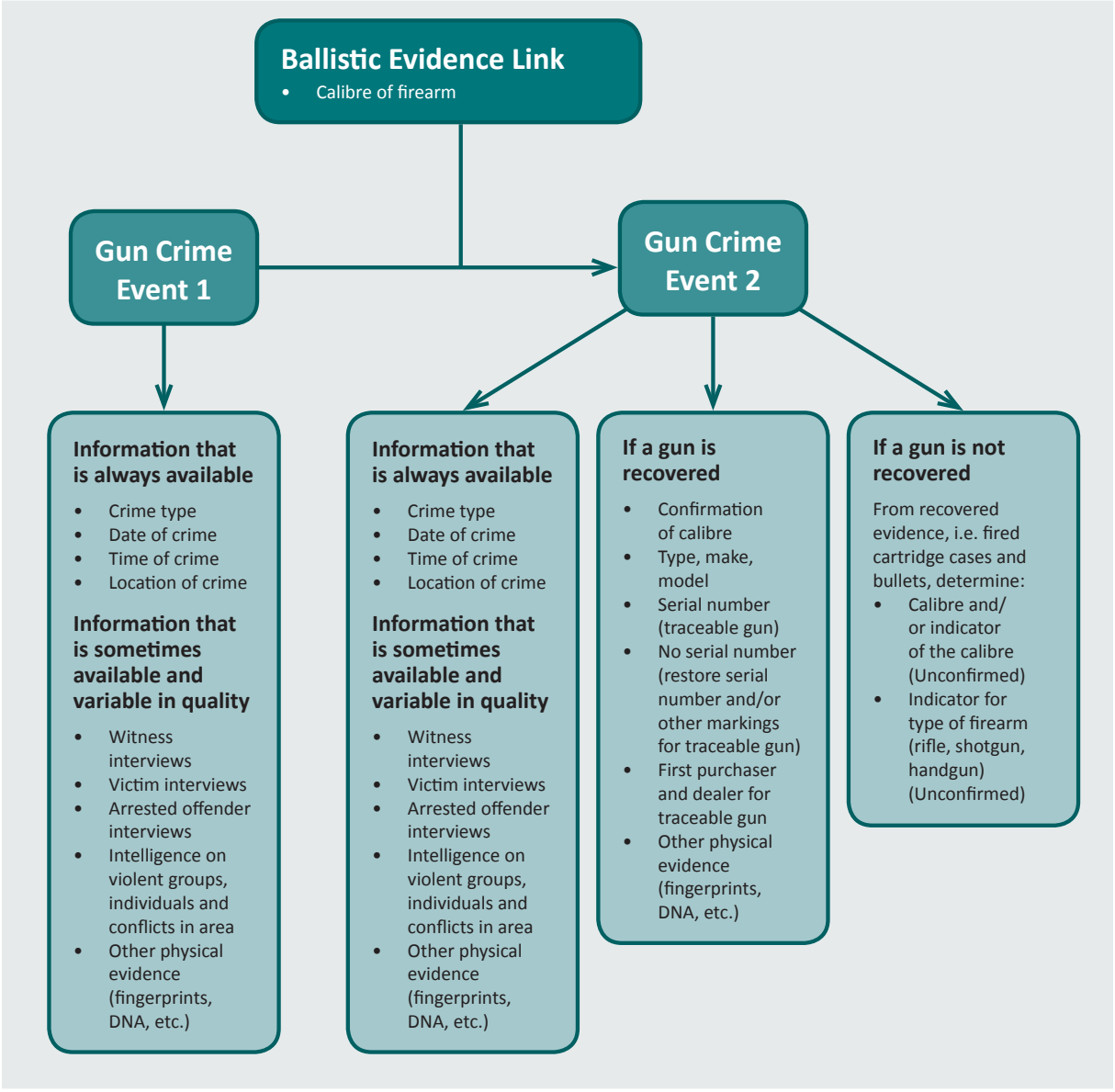
Ballistic evidence, ballistic information systems and criminal investigations

When a firearm is discharged it leaves unique microscopic markings on the surface of fired projectiles (commonly referred to as bullets) and cartridge cases. Forensic firearm examiners compare these markings to link cartridge cases and projectiles to crime scenes and recovered firearms. As part of a routine criminal investigation into a crime involving a firearm, police may recover cartridge cases and/or projectiles from the crime scene and then seize a firearm from a suspected offender. These two (or more) exhibits will then be compared to confirm whether the firearm was used in the commission of the alleged offence.

Forensic firearm examiners will also attempt to identify matches between two separate case exhibits—fired projectiles or cartridges from crime scenes or recovered firearms—for cases that were not previously known to be related. A match is known as a cold hit. Importantly, a cold hit does not link a firearm or crime scene to an individual and automatically result in the identification of an offender—the match is between the fired projectile or cartridge case and a test-fired projectile or cartridge case from a seized firearm involved in another incident or recovered from another crime scene. However, when two separate cases are found to have involved the same firearm, investigators are able to access additional evidence besides ballistic information from the linked investigation. This evidence could include interviews with witnesses, victims, or persons of interest, intelligence on violent groups or individuals and past incidents, and other physical evidence, such as DNA (Braga 2008).

The type of information that may be accessible from two linked investigations is described in Figure 1. Both the quality and quantity of additional evidence available will influence whether a cold hit will benefit a criminal investigation. If the linked investigation was unable to obtain much in the way of additional evidence—because victims or witnesses were unwilling to cooperate or because a firearm was not recovered, for example—then the likelihood that the cold hit will benefit investigators is likely to be much lower.

Figure 1: Types of information accessible from investigations linked by ballistic evidence



Source: Adapted from Braga 2008: 296; with contributions from NSWPF.

Automated ballistic systems

The advent of automated ballistic imaging and analysis systems in the 1990s significantly improved the capacity of law enforcement to identify links between investigations into firearm crime (Braga & Pierce 2004). In the past, the time required to manually compare two specimens under a microscope to identify and compare markings between two or more exhibits, and the volume of exhibits held by law enforcement organisations, meant that comparisons were typically limited to those situations in which there was intelligence suggesting two cases were linked (Cork et al. 2008).

A ballistic information system is a computerised database that stores digital images of bullets and cartridge cases and automatically compares these with new images acquired from crime scenes or test fires and uploaded to the database (King et al. 2013). Automated systems reduce the amount of time spent manually searching through potential matches to fired projectiles and cartridge cases by providing a small number of correlations within minutes for manual verification by a trained ballistic expert (Braga & Pierce 2004; Yang et al. 2014). This increases the probability of obtaining a match because the volume of exhibits that can be compared is increased.

The development of national and international collections of ballistic information enable police to electronically capture, match and correlate bullet and cartridge case images against other images locally (ie within the same jurisdiction), nationally (across state and territory borders) and internationally. This has the potential to increase the effectiveness of the police response to firearm-related crime where firearms are used in multiple crimes across more than one police jurisdiction.

Many countries have now established networks to enable national and international access to the images stored in automated ballistic systems. Since 2009, INTERPOL has managed the world's first international cross-border ballistic system, known as the INTERPOL Ballistics Information Network (IBIN). More than 19 countries and territories use IBIN (INTERPOL 2016). In the United States, the National Integrated Ballistic Identification Network (NIBIN) was established in 1999, although other systems have been in operation since the early 1990s. NIBIN is available to all police jurisdictions at both federal and state levels and uses the Integrated Ballistics Identification System (IBIS) technology (King et al. 2013). Finally, the United Kingdom established a national electronic ballistic information system, the National Ballistic Intelligence Service, in 2008.

The first automated ballistic system to be used in Australia was introduced in NSW in 2000. The NSW Police Force (NSWPF) adopted the IBIS technology in 2000 in response to increasing levels of firearm-related crime throughout the 1990s. A number of other jurisdictions then adopted the technology between 2007 and 2013. The first was the Australian Federal Police, followed by South Australia Police in 2012 and the Queensland Police Service in 2013. While these jurisdictions had access to automated ballistic identification systems, they were not linked. In July 2014, the Australian Ballistics Information Network (ABIN) became fully operational as a national system. The ABIN is managed by the Australian Criminal Intelligence Commission and uses the IBIS technology to provide a national automated ballistic information system to Australian police agencies, thereby enabling both local and national cold hits.

There are more than 60,000 exhibits—projectiles and cartridge cases—currently stored within the ABIN, of which 70 percent relate to criminal matters. As at the end of October 2016, there have been 845 cold hits obtained since automated ballistic systems were first introduced in Australia (by the NSWPF in 2000). In the 22 months following July 2014, when the ABIN was first implemented, there were 208 cold hits—equivalent to 1.7 cold hits per week. This includes 15 national hits (ie hits between cases in at least two police jurisdictions), which is reportedly more than occurred in the entire decade prior to the ABIN being available. However, what is not clear from these data is whether these cold hits have benefited investigators by increasing the amount of evidence available from linked investigations.

Prior research into the impact of automated ballistic systems

Consistent with patterns in research into police investigative techniques more broadly (Higginson, Eggins & Mazerolle 2017), only a small number of studies have examined the impact of ballistic evidence from automated ballistic systems. Evidence from an evaluation of the use of IBIS technology in Boston showed that IBIS cold hits generated significant investigative leads in 39 percent of the 44 hits analysed, including three in four homicide matches (Braga 2008). While this may have contributed to improved investigation outcomes (ie arrest, prosecution and conviction of an offender), the experience in Boston highlighted the challenges associated with confirming the identity of an offender or, where the identity of a person of interest was known, linking that individual to a particular incident (Braga 2008). For example, in 15 cases an arrest was made for the current offence, but there was no potential for additional charges for the linked investigation. Similarly, in 12 cases there were no arrests and no immediate charges based on the linked information.

Findings from the most recent evaluation of the US ballistic information system, NIBIN (King et al. 2013) were not as positive as the Braga (2008) study. Based on interviews with 65 investigators (from a sample of 104 cases), the research found that NIBIN hits did not assist investigators in the majority of cases reviewed. In 50 percent of the cases reviewed a suspect had been identified prior to receiving details about the linked investigation, and in 34 percent of cases the suspect had been arrested prior to the NIBIN hit notification (Table 2). The NIBIN hit report did help to identify a suspect in 10 percent of cases (n=6), led to an arrest in one case, helped in charging a suspect or obtaining a plea in three cases, and helped with sentencing in one case. In addition, some investigators reported using hit reports to eliminate a suspect from consideration or to confirm suspicions about suspects who may be involved with the crime (King et al. 2013).

Importantly, the evaluation found that the delay in notifying investigators of a hit severely limited the impact of the NIBIN. There were substantial differences in the way that labs processed ballistics information and the time it took for ballistic evidence to be uploaded to NIBIN (King et al. 2013). The length of time between the receipt of evidence and input into NIBIN ranged from zero days to 730 days (King et al. 2013). The amount of information contained within hit reports also varied—some contained the bare minimum, while others included additional information for the benefit of investigators.

Further, there was evidence that the NIBIN was not being used by the different jurisdictions to the full extent of its ability. Linking firearms involved in three or more criminal incidents may indicate the involvement of gangs, criminal enterprises or serial criminals. Only 11 percent of labs reported that they routinely provided information on three or more linked firearm incidents to different areas of law enforcement, such as organised crime units or gang task forces, or to crime analysis units. King et al. (2013) argued that this limited the potential strategic intelligence derived from the NIBIN.

Aims and method

In light of the findings from the United States, and given the significant investment in the ABIN by Australian police agencies, the aim of the current study was to determine the impact of ballistic evidence on criminal investigations into firearm crime in an Australian context. Specifically, the current study sought to answer the following research questions:

- What impact do cold hits obtained via the ABIN have on criminal investigations into firearm crime?
- To what extent do investigators use the information obtained through a cold hit to help inform their own investigations?
- Are certain investigations, such as those involving organised crime groups, more likely to benefit from a cold hit?
- Are there any implementation factors that have limited the benefits of cold hits for investigators?

A similar methodology to the US evaluations of the IBIS technology and the NIBIN was used to determine the impact of ABIN cold hits on investigation outcomes. This involved conducting brief interviews with police officers involved in the investigation of firearm crimes to examine the benefits to the investigation of additional information obtained through ABIN cold hits. The interviews were structured and included both multiple choice and open-ended response items. Questions related to the type of firearm offence investigated, whether the case involved organised crime, the types of evidence available to investigators prior to the hit and the evidence available to them from the linked investigation. Investigators were also asked about how the hit and linked investigation assisted and influenced the direction of their investigation and, if not, why not.

The researchers obtained contact details of investigators who received cold hits through the NSWPF and Victoria Police between January 2014 and December 2015. From an initial sample of 121 cold hits involving 194 unique cases, the research team were given contact details of investigators involved in 133 criminal investigations. The research team conducted follow-up interviews with investigators from 60 criminal investigations involving a total of 49 cold hits. The research team attempted to contact investigators who worked on the remaining 73 cases. Six investigators declined to participate due to the sensitive nature of the investigations, and 67 investigators could not be contacted. This resulted in a response rate of 45 percent.

Limitations

There are some important limitations to the current study that must be acknowledged. The overall response rate to the case file questionnaire was 45 percent, based on the total number of investigators whose contact information was available. However, this represents just 31 percent of all cases that resulted in a cold hit during the study period. Further, it was only possible to interview investigators for both the primary and secondary investigations for a small number of hits (n=10). The results may not be representative of the entire sample of cold hits and linked investigations.

The relatively small sample size also prohibited more detailed analysis. Specifically, while some attempt has been made to understand which cases benefited most from a cold hit, this additional analysis was limited somewhat by both the number of cases and also the information available about each investigation.

Importantly, the number of hits making up the sample size used for the current study (n=49) compares favourably with previous research in the United States (Braga 2008), which also relied on a similar sample size (n=44). Similarly, the number of interviews completed is similar to that used in the evaluation of the NIBIN (King et al. 2013), which was based on 65 interviews with investigators. The sample size, while relatively small, is therefore comparable with those used in international research into the impact of ballistic evidence on investigation outcomes.

A further limitation relates to the subjective nature of the assessments made by investigators regarding the impact of the ballistic evidence on their investigations. Some investigators found it difficult to separate the ballistic evidence from other developments in the investigation. Moreover, the assessments made by officers are likely to be influenced by the value they place on ballistic evidence—possibly based on past experience—relative to other investigative techniques. Some officers may have been unwilling to criticise the new system and therefore overstated the benefits of the ballistic evidence. Others may have placed greater weight on more traditional investigation methods for fear of downplaying the role of investigators. An attempt was made to overcome these limitations by asking officers to describe, in some detail, the impact of the ballistic evidence and then use this information to code response items following the interview.

Results

Sample characteristics

Offence characteristics for the sample are presented in Table 1. The most common principal offence type for the cases included in the sample was unlawful use of a firearm or discharge of a firearm at prohibited places, which accounted for almost two-thirds (62%) of the entire sample. The next most common principal offence types were murder (12%) and attempted murder (10%). Sixty-two percent (n=37) of investigations were active at the time of the hit being obtained.

Table 1: Characteristics of the linked investigations (n=60)		
	n	%
Principal offence		
Unlawful use of a firearm/discharge of firearm at prohibited places	37	62
Murder	7	12
Attempted murder	6	10
Dispose firearm/ammunition to unlicensed person, sell without a dealer's licence	4	7
Assault	3	5
Robbery involving use of a weapon	3	5
Organised crime involvement		
Organised crime was involved	32	53
Investigator was unsure if organised crime was involved	18	30
Organised crime was not involved	10	17
Investigation status when hit occurred		
Active investigation	37	62
Inactive investigation	17	28
Finalised investigation	5	8
No longer in charge of case	1	2

Note: Principal offences based on Australian and New Zealand Standard Offence Classification. Percentages may not total 100 due to rounding
Source: Detailed case analysis 2016 [AIC data file]

Half of the investigations related to incidents that involved organised crime groups (53%; n=32), although it was unknown whether organised crime was involved in a further 30 percent (n=18) of investigations. This means that, among those cases where it could be confirmed, organised crime was involved in 76 percent of incidents investigated. An important aim of the ABIN was to help establish a national picture of the criminal use of firearms in Australia and the associated organised crime groups that use them. These findings suggest that organised crime groups play a significant role in cases of firearm-related crime in Australia where firearms are used in multiple incidents. Interviews with police representatives revealed that the cold hits provided useful intelligence and contributed to a general intelligence picture, particularly in relation to organised crime group activity and movements.

Evidence from linked investigations

One of the primary mechanisms through which the ABIN was expected to benefit investigators was through the improved evidence available resulting from investigations being linked. Investigators were asked what evidence was available to them prior to being advised of the linked investigation (Table 2). Evidence obtained from interviews with witnesses, victims and offenders was identified as the most common type of evidence available prior to a hit, available in 67 percent of investigations (n=40).

However, investigators also noted that often witnesses or victims did not wish to assist police, particularly in organised crime related incidents, and therefore only limited information was obtained from these interviews. The next most common type of evidence was intelligence (27% of investigations) and other forms of evidence (20%), followed by physical (13%) and surveillance evidence (13%). The types of evidence in the 'other' category included evidence gathered via search warrants, line-ups and covert operations. Investigators reported that there was no other evidence available prior to the hit in 27 percent of investigations.

Table 2: Evidence available pre-hit and additional evidence post-hit due to investigations being linked (n=60)				
	Evidence available pre-hit		Additional evidence available as a result of linked investigation	
	n	%	n	%
Interviews (witness, victim and offender)	40	67	4	7
Intelligence (informants and intelligence on violent groups)	16	27	3	5
Physical evidence (DNA, fingerprints and post-mortem reports)	8	13	5	8
Surveillance (CCTV, electronic evidence, intercepted telephone conversations)	8	13	3	5
No evidence available	16	27	41	68
Other evidence	12	20	9	15

Note: Investigators could identify multiple types of evidence available for each case
Source: Detailed case analysis 2016 [AIC data file]

The types of additional evidence that were available to investigators post-hit are also presented in Table 2. The most frequently cited new evidence type was physical evidence—DNA evidence, fingerprints and post-mortem reports (n=5; 8%). Additional interview evidence was available in four cases (7%). There were nine cases where investigators reported that there was other evidence not easily categorised, including surveillance from unrelated investigations. Overall, investigators were able to identify additional evidence as a result of the linked investigation in 32 percent of all investigations. In the remaining 68 percent of investigations there was no new evidence available from the linked investigation. However, hits that did not result in additional evidence could still benefit an investigation, particularly where a linked investigation was well advanced (eg the offender had been charged or was before the court).

Impact on investigation process or outcomes

Overall, there were 26 cases (43%) where the hit provided direct assistance to investigators. In 12 cases (20%) investigators stated that the hit provided significant investigative leads, in seven cases (12%) the hit led to the arrest of a suspect and in another seven cases (12%) an offender was identified from the linked investigation but had not yet been apprehended. The impact in two cases was unknown.
For the remaining 32 cases (53%), there was no direct impact on the investigation; however, the ABIN hit was frequently reported as having provided general intelligence. That is, while it may not have assisted with their specific investigation, it was felt that it provided additional contextual knowledge, ruled out alternative lines of investigation, or would be useful for future investigations (Table 3).

Table 3: Impact of cold hits on investigations (n=60)		
	n	%
Provided significant investigative leads	12	20
Identified an offender (not yet apprehended)	7	12
Led to arrest	7	12
No direct impact on investigation (provided general intelligence)	32	53
Unknown	2	3
Total	60	100

Source: Detailed case analysis 2016 [AIC data file]

Further analysis examined a number of variables that were thought to influence the likelihood of a cold hit having an impact on an investigation. The bivariate relationships between these variables and a new variable—whether the hit had a direct impact on the investigation—are presented in Table 4. The relatively small sample meant that each variable could only be examined in isolation.

A cold hit was more likely to assist an investigation when the time between the offence and the investigator being notified of the hit was 30 days or less compared to when it took longer than 30 days (62% vs 39%), although this difference was not statistically significant based on a chi-square test of association (χ^2=1.84, *p*=0.18). A smaller difference was also observed at two months (52% vs 39%) and at three months (48% vs 41%). The median number of days for hits that did assist an investigation was also lower than for those hits that did not have a direct impact on the investigation (51 days vs 66 days), although this difference was also not statistically significant based on a Wilcoxon-Mann-Whitney test (z=0.72, *p*=0.47). This finding was consistent with the view of investigators, both as part of the current study and also the King et al. (2013) evaluation of the NIBIN, which was that the length of time it took to receive a hit notification did influence whether the hit benefited the investigation. The results from this analysis, although based on a relatively small sample size, provide tentative support for this conclusion.

The time it takes from an offence date until an investigator is notified of a cold hit is determined by a number of factors. This includes whether it is the investigation that resulted in the hit (secondary investigation) or the investigation that provided the original evidence (primary investigation). It also depends on how long it takes an investigator to submit the evidence to the ballistics unit, and the priority level assigned to ballistic analysis processes. Finally, there is the time that a ballistics unit takes to process the information—while the initial match may be identified quickly, the (necessary) peer review processes required to confirm the hit and obtain a forensic certificate add additional time to the process.

Table 4: Relationship between investigation characteristics and impact of cold hit (n=59)				
	Assisted		Did not assist	
	n	%	n	%
Time from offence to hit notification[a]				
30 days or less	8	62	5	38
More than 30 days	13	39	20	61
Median days	51		66	
Organised crime[b]				
Involved	14	45	17	55
Not involved	7	70	3	30
Investigation status when hit occurred[c]				
Active investigation	16	43	21	57
Inactive investigation	9	53	8	47

Note: Excludes 1 case where the impact of the investigation was unknown due to staff turnover
a: Excludes 14 cases with missing data on either the date of the offence or the date of the hit notification
b: Excludes 18 cases where it was unknown whether organised crime was involved
c: Excludes 5 cases in which the investigation was finalised prior to hit
Source: Detailed case analysis 2016 [AIC data file]

Importantly, feedback from investigators about the timeliness of the process was very positive—81 percent of investigators were satisfied or very satisfied with the process of obtaining a hit. Additional feedback from investigators praised the speed with which they were notified by ballistics units about the outcome of ballistic evidence analysis (typically by email in the first instance) and the quality of information provided.

The proportion of cases not involving organised crime that benefited from a cold hit was higher than for those cases that involved organised crime (70% vs 45%), although this difference was not statistically significant based on a Fisher's exact test (p=0.16). This excluded cases where the involvement of organised crime was unknown. Importantly, the fact that the majority of cases did involve organised crime means that a higher number of organised crime investigations (n=14) were directly assisted by a cold hit.

Active and inactive investigations were also compared. Once again, the difference in whether the investigation benefited from the hit was not statistically significant (χ^2=0.44, p=0.51). Inactive investigations were as likely, if not more likely, to benefit from a cold hit as investigations that were still active at the time of investigators being notified of a hit (53% vs 43%). This is an important finding, as it suggests that ballistic evidence has just as much potential to benefit investigations that have been suspended due to lack of evidence as investigations that are ongoing.

Finally, investigators who reported that the hit had no direct impact on their investigation (n=32) were also asked the reasons why they believed the linked investigation did not assist (Table 5). The most frequently cited reason was that the linked investigation did not provide new evidence that directly benefited the investigation—the hit was of general investigative or intelligence value only (n=11; 34%). The next most common reasons were that the hit linked the firearm but did not identify a suspect (n=7; 22%) and the hit details confirmed intelligence already known by police (n=7; 22%). In one case the suspect was identified prior to the hit information being received. Further, in two cases, the linked investigation identified a suspect; however, the suspects involved in those cases were deceased (included in the 'other' category).

Table 5: Reasons why the linked investigation had no direct impact on the investigation		
	n	%
Linked investigation did not provide new or additional evidence that benefited the investigation (only general investigative and/or intelligence value)	11	34
The hit linked the firearm but did not identify a suspect	7	22
Hit details confirmed intelligence already known	7	22
Suspect identified, but charges were not filed due to lack of evidence	3	9
Suspect identified prior to hit information being received	1	3
Other	3	9
Total	32	100

Source: Detailed case analysis 2016 [AIC data file]

Discussion

The results of this study must be understood within the broader context of firearm crime in Australia. Compared with other international jurisdictions, firearm crime in Australia is a relatively rare event (Lemieux, Bricknell & Prenzler 2015). For multiple incidents to involve the same firearm is even rarer, and the pattern in cold hits obtained by the ABIN suggests these incidents are concentrated among organised crime groups operating on the east coast of Australia. Technology like the ABIN can therefore only ever assist a certain segment of criminal investigations into firearm crime.

Traditional law enforcement methods therefore remain vitally important. There are many other investigative tools and techniques available to investigators that contribute to improved clearance outcomes for serious and violent crime, including firearm crime (Higginson, Eggins & Mazerolle 2017).

Nevertheless, the results from the current study showed that ballistic evidence from the ABIN (and IBIS before that) provided direct assistance to investigators in almost half of the cases examined. These results compare favourably to the results of US evaluations of the IBIS technology in Boston and the NIBIN (Braga 2008; King et al. 2013). Given there have now been more than 800 cold hits since NSWPF first implemented the technology in 2000, and more than 200 hits since the network was expanded nationally, the actual number of cases that will have benefited from this technology is likely to be substantial.

Importantly, linking investigations on the basis of ballistic evidence was just as likely to benefit investigations that had been suspended due to lack of evidence (ie cold cases) as investigations that were ongoing. Research has previously shown that homicides involving a firearm are less likely to be cleared than homicides involving other causes of death, largely because of the limited physical contact that occurs between victim and offender and because there is less likely to be a relationship between the victim and offender (Alderden & Lavery 2007). Similar issues are likely to affect investigations into drive-by shootings, which were also common among the investigations in this study. Further, clearance rates for serious and violent crimes have either stabilised or declined in recent decades (Worrall 2016), highlighting the importance of new methods for solving cold cases.

Cases involving organised crime—which were common among the cases that obtained a cold hit—also appeared to benefit from ballistic evidence. This is important, given the annual cost of the law enforcement response to serious and organised crime, including criminal investigations, has been estimated at more than $3 billion nationally (Australian Crime Commission 2015). The fact that they were less likely than cases not involving organised crime to benefit from a cold hit probably reflects the ongoing challenges of gathering evidence from reluctant victims and witnesses involved in organised crime groups (Regoeczi, Jarvis & Riedel 2008). Cases are more likely to be cleared when witnesses are willing to provide information (Baskin & Sommers 2010).

There were two main reasons that cases did not benefit from a cold hit. The most common reason was that the linked investigation provided no additional evidence to aid investigators. Ballistic evidence alone does not identify the perpetrator. If the evidence obtained from the initial investigation is insufficient for police to solve a case, then a cold hit will only add benefit if it results in new evidence from the linked investigation. This might include DNA evidence, other forms of physical evidence, or information on suspects obtained from computer databases and interviews, which have each been shown to benefit investigators, although the evidence is mixed in some cases (Higginson, Eggins & Mazerolle 2017).

The second reason was that significant progress had already been made with the investigation—a small proportion of cases had already been finalised prior to the hit being obtained, while in others the suspect had already been identified and there was little benefit to be gained from a linked investigation. Past research has shown that serious crimes are most likely to be solved soon after the incident, and that the probability of case clearance declines markedly over time (Worrall 2016). This may limit the need for ballistic evidence analysis or, more likely, result in it being used to confirm what is already known about the incident or suspect.

Consistent with this finding, the results showed that the timeliness of ballistic evidence analysis was important; however, there was little evidence of the same issues affecting the NIBIN in the United States (King et al. 2013). While the technology is new to several states and territories, NSWPF—one of the two police agencies included in the current study—has had the technology for 16 years. The area responsible for managing the system is well resourced and has highly qualified and experienced technicians responsible for handling forensic firearm evidence. Protocols exist for prioritising cases and providing information to investigators. It was evident from the current study, based on the feedback from investigators about the timeliness of evidence analysis and the quality of information provided when there was a hit, that the group responsible for ballistic evidence was responsive to the needs of investigators. Importantly, in rolling out the ABIN to other states and territories, other police agencies relied on NSWPF as a model to replicate (acknowledging the significant variation in demand and resourcing), with oversight from the CrimTrac agency (now the Australian Criminal Intelligence Commission), potentially avoiding some of the variability in implementation reported in the United States.

There is nonetheless still scope to improve the use of ballistic evidence by investigators. This is by no means unique to ballistic evidence. In fact, research has consistently shown that, while DNA evidence significantly increases the likelihood of conviction (Wilson, Weisburd & McClure 2011), there remains some resistance among investigators to relying on this and other forms of forensic evidence (Shroeder & White 2009). Similar issues have been detected with technological advancements in

policing more broadly, primarily because of technical constraints, real and perceived unintended consequences for officer productivity and organisational and cultural factors (Lum, Koper & Willis 2016). This research serves as an important reminder for police to integrate ballistic evidence collection and analysis as an important component of investigations into firearm crime. While it is still relatively early days in the national rollout of an automated ballistic information collection system, the majority of cold hits have been obtained in New South Wales and Victoria—it remains to be seen whether this pattern will change over time, and whether this reflects patterns in firearm crime or the level of support for ballistic evidence analysis in other jurisdictions.

Finally, while the results of this study are promising, future research could measure the impact of ballistic evidence and cold hits by relying on more objective indicators such as clearance rates (or time to clearance), and by employing a more rigorous research design. However, any such study would need to account for the breadth of investigative techniques employed by police investigating serious crime. If this can be achieved, it would be another important contribution to an area of policing research that remains significantly underdeveloped (Koper, Lum & Willis 2014).

Conclusion

Modern police agencies have embraced new technologies as a way of overcoming the limitations of traditional methods of policing and crime control. Research into the impact of these new technologies is important, particularly given the significant costs that are often associated with not just the infrastructure but also the police time required to use and manage the technology. Overall, this study has provided some promising evidence in support of using ballistic evidence obtained through a national automated ballistic information network in investigations into firearm crime. It makes an important contribution to an otherwise limited body of Australian research into the efficacy of investigative techniques. It also highlights the value that empirical research can offer to our understanding of how new technology supports police investigations, particularly in the area of serious and organised crime.

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