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Toxicology and Circumstances of Death of Homicide Victims in New South Wales, Australia 1996–2005

ABSTRACT: To determine the prevalence and circumstances of psychoactive substances amongst homicide victims, 485 consecutive cases autopsied at the NSW Department of Forensic Medicine (1/1/1996–12/31/2005) were analyzed. Substances were detected in 62.6% of cases, and illicit drugs in 32.8%. Alcohol, cannabis, opioids, and psychostimulants were most commonly detected. Alcohol and cannabis were both more prevalent amongst males. Mean ages were significantly younger for decedents who tested positive for a substance and for an illicit drug. Cases where death resulted from a physical altercation were more likely to have had alcohol and cannabis present. Illicit drugs were prominent amongst firearms deaths. The proportion of alcohol positive cases increased from 25.0% on Monday to 49.4% for Saturdays/Sundays. Alcohol was more common in incidents in the 0001–0600 h and 1800–2400 h periods. Psychoactive substances appear to substantially increase the risk of homicide, although there are important differences between drug classes in the circumstances of such incidents.

KEYWORDS: forensic science, homicide, toxicology, illicit drugs

An association between substance use and violence has been long recognized (1–3). Most prominently, alcohol has been associated with an increased likelihood of committing violent acts (4–7), and variations in homicide rates have been linked to alcohol sales volumes (8). The association is not restricted to alcohol, with illicit drugs (particularly methamphetamine, cocaine, and opioids) also associated with increased levels of violence (1–3,5).

The causes of such an association relate to the psychopharmacological effects of the individual drug, and the circumstances surrounding substance use. Much alcohol-related violence may be directly attributed to the disinhibiting effects of the drug itself (1–3). Similarly, psychostimulants are associated with symptoms such as paranoia and agitated delirium, which may substantially increase the risk of violence (9,10). The circumstances of illicit drug use, particularly dependent use, increase the risk of violence. Illicit drugs are expensive, and high levels of crime are performed to support such drug use, or to protect drug dealing networks (11–14). At the psychological level, there is also a strong association of both Antisocial and Borderline Personality Disorders with substance dependence, diagnoses specifically associated with impulsivity, risk-taking, and violent behaviors (9).

With the pharmacological, circumstantial, and psychological links between substance use and violence, high rates of substance use would be expected amongst perpetrators of violent crime. Such, indeed, appears to be the case, with as many as a third of homicide offenders positive for illicit drugs and/or alcohol at the time of their offence (15–18).

Given this overall picture, substance use might be also expected to play a significant role among victims of violence. The research is not extensive, but this appears to be the case. Histories of having experienced an assault, and of Post Traumatic Stress Disorder, are common amongst heavy alcohol and illicit drug users (19–22), and homicides constitute a substantial proportion of fatalities amongst substance users (11). Whilst few studies have been conducted, and those overwhelmingly from the United States, large proportions of homicide victims appear positive for alcohol and/or illicit drugs (14,23–28). By way of illustration, among New York homicide victims alcohol was present in 30%, cocaine in 28%, cannabis in 19%, and opiates in 11% (28). The high salience of cocaine use in the U.S. was demonstrated by the fact that the homicide rate covaried with the rate of cocaine positive cases. There was also a strong association between firearm deaths and cocaine, much of which is attributed to crack-related gang violence (23,28).

While it appears that substance use plays a significant role amongst homicide victims, few studies have examined in detail the relationships between toxicological patterns, demographic characteristics, or circumstances of death. The current study aimed to examine in detail the relationship of licit and illicit drug classes to the demographics and circumstances of homicide over a 10-year period. Specifically, the study aimed to:

1. Determine the prevalence of psychoactive substances amongst homicide victims over the period 1996–2005;
2. Determine the relationship between the presence of psychoactive substances and victim demographic characteristics; and
3. Determine the relationship between the presence of psychoactive substances and circumstances of the fatal incident.

Methods

Case Identification

Autopsy reports and police summaries of all cases of suspicious death aged between 15 and 60 years who underwent autopsy at the New South Wales (NSW) Department of Forensic Medicine between January 1, 1996 and December 31, 2005 were retrieved.

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This age range was selected, as it represents the range that encompasses almost all illicit drug use (29). All cases where death was due to murder or manslaughter were included, and cases of suicide or self-administered drug overdoses excluded. The NSW Department of Forensic Medicine is located in central Sydney, and is the primary forensic pathology center in NSW, conducting approximately 2000 autopsies per year. Permission to inspect the files was received from the Sydney South West Area Health Service human research ethics committee. All cases were reviewed by the authors.

In NSW, a case must be reported to the Coroner where a person dies a violent or unnatural death. All such cases undergo a standardized forensic autopsy, with examination of all major organs and quantitative toxicological analysis. Cause of death is determined by the forensic pathologist on the basis of circumstances of death, the comprehensive autopsy findings, and the toxicological analyses.

Specific data retrieved from the autopsy and police reports included: cause of death, the demographic characteristics of victims, the location where the fatal incident occurred, the time and date of the fatal incident, the social setting of the fatal incident, and the quantitative toxicological findings for each case. Toxicological data were reported for alcohol, cannabis (determined by the presence of Δ-9-THC), morphine (the primary metabolite of heroin), methadone, methamphetamine, cocaine (determined by the presence of cocaine itself and/or the presence of benzoylecgonine, the major metabolite of cocaine), 3,4methylenedioxymethamphetamine (MDMA), benzodiazepines, gamma hydroxy butyrate (GHB), antidepressants, antipsychotic medications, and steroids. All presented toxicological analyses were of blood. Quantitative data are presented only for alcohol. In cases where there was prolonged hospitalization prior to death, antemortem toxicology was reported where available, otherwise toxicology was not reported. In all cases, drugs administered by hospital and medical staff were excluded.

Statistical Analyses

Where distributions were highly skewed, medians and inter-quartile ranges (IQR) were reported, otherwise means were presented. For bivariate comparisons, t-tests or odds ratios (OR) with 95% confidence interval (CI) were reported. For analysis of nondichotomous categorical variables, chi-square analyses were conducted. All analyses were conducted using SPSS for Windows (release 14.0) (30).

Results

Cases

A total of 485 cases were identified. The mean age of decedents was 35.5 years (SD 11.4, range 15–60 years) and 70.9% were male, with no gender difference in age. Deaths were most commonly attributed to stabbing/cutting (35.7%), blunt force injuries (31.3%), and gunshot (26.4%). Less frequent causes of death were: strangulation/suffocation (8.0%), immersion (2.3%), fall from height (1.6%), hanging (1.0%), fire/smoke inhalation (1.0%), and poisoning/corrosive substances (0.6%). Multiple causes were identified in 7.0% of cases.

Circumstances of Fatal Incident

The two most common locations for the fatal incident to have occurred were a home environment (47.9%) and the street (25.5%).

Less frequent locations were: bushland (4.5%), a bar (3.9%), a car (3.3%), the victim's workplace (2.5%), water (2.1%), and prison (2.3%). Significantly more female cases occurred in a home environment (71.9% vs. 38.2%, OR 4.15, CI 2.70–6.37), while significantly more male cases occurred on a street (31.5% vs. 10.8%, OR 3.80, CI 2.12–6.80). The fatal incident occurred as a result of a domestic dispute in 20.9% of cases (females 49.3% vs. males 9.3%, OR 9.43, CI 5.78–15.38). In 26.3% of cases, the incident occurred in the context of a physical altercation, with males more likely to have been involved in such altercations (34.9% vs. 5.0%, OR 10.11, CI 4.58–22.32).

Fatal incidents were not uniformly distributed across days of the week ($\chi^2_6 = 24.9$, $p < 0.001$), with Fridays (16.0%), Saturdays (19.8%), and Sundays (18.0%) over-represented. Similarly, incidents were not uniformly distributed across time periods ($\chi^2_3 = 74.5$, $p < 0.001$): 0001–0600 h (35.2%), 1801–2400 h (35.0%), 1201–1800 h (20.0%), 0601–1200 h (9.9%).

Toxicology

Toxicology was available for 473 (97.5%) cases. Substances were detected in nearly two-thirds of cases, and multiple substances in a quarter (Table 1). More specifically, illicit drugs were detected in a third of cases, and multiple illicit drugs in nearly a tenth.

The most commonly detected substance was alcohol (present in nearly half of cases) with a median blood alcohol concentration of 0.14 g/100 mL (IQR 0.15, range 0.01–0.48 g/100 mL) among alcohol positive cases. The next most commonly detected substances were cannabis, opioids (predominantly morphine), and psychostimulants (predominantly methamphetamine). The most common drug combinations were: alcohol and cannabis (10.8%), opioids and benzodiazepines (4.4%), and cannabis and psychostimulants (3.8%). There were no significant differences across years in the proportions of cases positive for alcohol ($p > 0.2$), cannabis ($p > 0.9$), psychostimulants ($p > 0.9$), opioids ($p > 0.8$), or benzodiazepines ($p > 0.2$).

TABLE 1—*Toxicology of homicide victims, 1996–2005.*

	Males ($n = 337$) %	Females ($n = 136$) %	All ($n = 473$) %	Gender Comparisons
Global				
Substance detected	67.7	50.0	62.6	OR 2.09 (CI 1.39–3.14)
Multiple substances	26.1	22.1	24.9	Not significant
Illicit drug(s) detected	34.1	29.4	32.8	Not significant
Multiple illicit drugs	9.5	5.9	8.5	Not significant
Alcohol	46.0	32.4	42.1	OR 1.78 (CI 1.17–2.71)
Cannabis	24.0	14.7	21.4	OR 1.84 (CI 1.07–3.14)
Opioids	11.3	11.0	11.2	Not significant
Morphine	10.4	11.0	10.6	
Methadone	2.4	1.5	2.1	
Psychostimulants	9.5	10.3	9.7	Not significant
Methamphetamine	5.9	5.1	5.7	
Cocaine/ benzoylecgonine	3.3	3.7	3.4	
MDMA	1.8	1.5	1.7	
Benzodiazepines	8.6	6.6	8.0	Not significant
GHB	0.0	0.7	0.2	Not significant
Other drugs				
Antidepressants	1.8	2.9	2.1	Not significant
Antipsychotics	1.8	0.0	1.3	Not significant
Steroids	0.6	0.0	0.4	Not significant

TABLE 2—*Toxicology of homicide victims by circumstance of incident.*

| Circumstance | Drug Class | | | | | | |
	Any Substance (%)	Illicit (%)	Alcohol (%)	Cannabis (%)	Opioids (%)	Psychostimulants (%)	Benzodiazepines (%)
Place							
Home	60.4	31.3	40.1	20.7	11.5	8.4	10.1
Street	70.6	38.7	42.9	23.5	12.6	14.3	8.4
Domestic dispute							
Yes	57.0	29.0	42.0	21.0	8.0	6.0	4.0
No	64.4	34.0	42.3	21.6	12.1	10.8	9.2
Fight							
Yes	81.1	43.4	59.8	32.8	9.0	10.7	9.0
No	56.5	29.1	36.3	17.3	11.8	9.5	7.8
Method							
Stabbing	59.4	32.4	36.7	23.5	8.8	7.6	8.2
Firearms	63.8	39.4	37.5	24.4	13.4	15.0	6.3
Blunt force injuries	62.8	27.6	46.9	17.9	10.3	8.3	8.3
Time of day							
0001–0600	65.2	30.5	46.1	20.6	11.3	9.9	8.5
0601–1200	42.5	37.5	17.5	15.0	15.0	7.5	15.0
1201–1800	53.1	29.6	26.3	23.5	7.4	7.4	7.4
1801–2400	67.2	35.0	47.1	23.4	11.7	10.9	5.1

Toxicology and Demographic Characteristics—Males were significantly more likely to have a substance detected, but there was no gender difference for illicit drugs (Table 1). The only two substances where gender differences were noted were alcohol and cannabis, both more prevalent amongst males.

Mean ages were significantly younger for decedents who tested positive for a substance (34.6 years vs. 37.3 years, $t_{469} = 2.5$, $p < 0.05$) and for an illicit drug (32.3 vs. 37.2, $t_{469} = 4.5$, $p < 0.001$). Significantly younger mean ages were noted for those who tested positive for cannabis (31.4 years vs. 36.8 years, $t_{469} = 4.3$, $p < 0.001$) and psychostimulants (31.6 years vs. 36.1 years, $t_{469} = 2.6$, $p < 0.05$), but not for alcohol, opioids, or benzodiazepines.

Toxicology and Circumstances of Incident—There were no significant toxicological differences between the major locations of fatal incidents (Table 2). Not surprisingly, a high proportion of cases where the fatal incident occurred at a bar were alcohol positive (68.4%). There were also no significant differences in the presence of the major drug classes in deaths resulting from domestic disputes compared to other deaths, with over a half of those killed in domestic disputes being positive for a substance, and over a quarter positive for an illicit drug.

Over 80% of cases of deaths involving physical altercations were positive for a substance (OR 3.31, CI 2.01–5.47) and over 40% were positive for an illicit drug (OR 1.87, CI 1.22–2.87) (Table 2). Specifically, these cases were significantly more likely to be positive for alcohol (OR 2.61, CI 1.71–3.99) and cannabis (OR 2.33, CI 1.46–3.73).

Illicit drugs were prominent amongst firearm deaths, with the highest proportion of illicit drugs being seen in such cases (Table 2). The relative levels of psychostimulants in such cases was particularly pronounced, being twice as high as that seen in deaths due to other causes (OR 2.16, CI 1.15–4.04). In contrast, alcohol was most frequently seen amongst deaths due to blunt force injury.

Toxicology and Time of Incident—The proportion who tested positive for alcohol varied significantly across days of the week ($\chi^2_6 = 14.9$, $p < 0.05$), increasing from 25.0% on Mondays to 49.4% for incidents that occurred on Saturdays and Sundays (Fig. 1). Alcohol was 2.12 times (CI 1.38–3.27) more likely to be
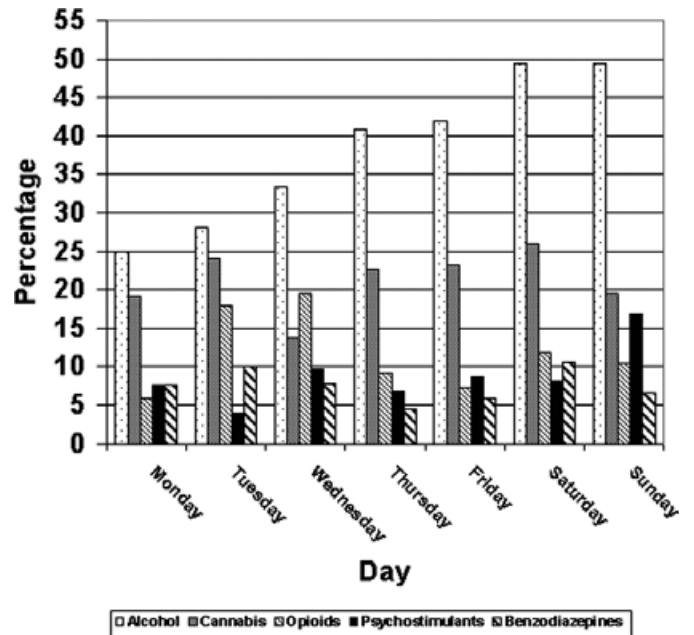

FIG. 1—*Presence of drugs by day of fatal incident.*

present in incidents that occurred on a Saturday/Sunday than on other days. There were no significant weekday differences in the proportions who tested positive for any other drug class.

There was a significant diurnal difference for substances being detected, being more common in the 0001–0600 h and 1800–2400 h periods ($\chi^2_3 = 11.1$, $p < 0.05$), but there was no diurnal variation in the probability of illicit drugs being detected (Table 2). More specifically, the only drug in which there was a significant diurnal difference was alcohol ($\chi^2_3 = 19.9$, $p < 0.001$), substantially more common for incidents that occurred in the 0001–0600 h and 1800–2400 h periods.

Discussion

The current study provides the most detailed examination of homicide, toxicology, and surrounding circumstances conducted to

date. Consistent with international research (14,23–28), psycho-active substances were highly prevalent. Multiple substance use prior to death was common. High levels of substance use were seen across all physical, temporal, and social circumstances. Consistent with the epidemiology of substance use in Australia (29), alcohol and cannabis were the most commonly detected substances. The levels of individual substances seen amongst these cases were distinct from those seen in the U.S., with psychostimulant levels (and cocaine in particular) substantially lower than those reported in the U.S. (14,23–28).

While these levels appear high, how do they compare to population statistics? Population use patterns are illustrative, with daily use providing the best comparison. For all major drug classes, population daily use prevalence is at far lower levels than those seen amongst decedents: alcohol (8.9%), cannabis (1.9%), methamphetamine (0.4%) and heroin (0.14%) (29). It is reasonable to conclude that the presence of these drugs substantially increased the risk of a fatal incident, whether through direct drug effects or through violence surrounding the use of these drugs.

The high proportion of illicit drugs, and multiple illicit drug use, illustrates the range of risks associated with the use of these substances. Illicit drug use is associated with highly elevated rates of mortality. While the primary causes of this elevated mortality are overdose and disease, homicides constitute substantial proportions of cases (11). The current data indicate that illicit drug use makes a large contribution among homicide victims *per se*, whether through disinhibition, associated lifestyle risks, or increased vulnerability whilst intoxicated.

While males were significantly more likely to have alcohol and cannabis detected, no gender differences were noted for other drugs. In all probability this reflects the high levels of danger surrounding the use of illicit drugs such as heroin and methamphetamine, and of dependent drug use in particular. Consistent with this, longitudinal studies of opioid and psychostimulant users repeatedly report no gender difference in all-cause or trauma-specific mortality rates (11). The finding that younger ages were associated with cannabis and psychostimulants is consistent with the population prevalence of these drugs (29).

Substances were common across different social circumstances associated with fatal incidents, with high proportions present amongst victims of domestic violence and of physical altercations. Over half of domestic violence victims had substances present, a rate not significantly different from other circumstances. Physical altercations were associated with particularly high levels of substance use, a scenario strongly associated with males. Specifically, the presence of alcohol and/or cannabis occurred at substantially higher levels in these cases than in deaths in other circumstances. This may reflect disinhibition, or a tendency to belligerence or to take offense when under the influence of these drugs. Cannabis may also be a marker for broader illicit drug involvement.

There were distinct differences between individual substances and the circumstances surrounding fatal incidents. The highest proportion of illicit drug positive cases were seen amongst firearms cases, while the highest proportion of alcohol positive cases were seen in blunt force injury cases. Consistent with U.S. research (23,28), firearms were particularly associated with psychostimulants (primarily methamphetamine). What should be borne in mind is that firearms ownership is heavily restricted in Australia, and gun ownership uncommon. Such a high proportion of deaths from firearms is consistent with the strong association between outlaw motorcycle gangs and methamphetamine production in Australia (31), and the paranoia and agitated delirium associated with

psychostimulant use. By contrast, as noted above, alcohol was strongly associated with physical altercations and appeared circumstantial, rather than representing sustained risk.

A pronounced weekly cycle was noted for alcohol. This is consistent with the scenario of week-end binge drinking fueling alcohol-related violence. In contrast, drugs such as the opioids showed no such patterns, suggesting constant rather than situational risk, which is consistent with the daily use patterns of dependent illicit drug users. Alcohol was also the only drug to demonstrate diurnal differences, again reflecting situational rather than sustained risk. If we were to characterize a particularly high risk circumstance for males, it would be alcohol positive in a public place in the late evening/early morning on a weekend. For females, the same scenario would apply, except that the risk would relate to a domestic dispute in a home environment.

In summary, psychoactive substances were highly prevalent, including a high proportion of illicit drugs. While such substances are strongly associated with increased risk for overdose and disease risk, they also appear to substantially increase the risk of death through homicide.

References

1. Athanasiadus L. Drugs, alcohol, and violence. Curr Opin Psychiatry 1999;12:281–6.
2. Boles SM, Miotto K. Substance abuse and violence. A review of the literature. Aggr Viol Behav 2003;8:155–74.
3. Parker RN, Auerhahn K. Alcohol, drugs and violence. Annu Rev Sociol 1998;24:291–311.
4. Ellickson PL, Tucker JS, Klein DJ. Ten-year prospective study of public health problems associated with early drinking. Pediatrics 2003;111:949–55.
5. Lennings CJ, Copeland J, Howard J. Substance use patterns of young offenders and violent crime. Aggress Behav 2003;29:414–22.
6. Scott KD, Schafer J, Greenfield TK. Role of alcohol in physical assault perpetration and victimization. J Stud Alcohol 1999;60:528–36.
7. Wells S, Graham K. Aggression involving alcohol; relationship to drinking patterns and social context. Addiction 2003;98:33–42.
8. Rossow I. Alcohol consumption and homicides in Canada, 1950-1999. Contemp Drug Probl 2004;31:541–59.
9. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 4th ed., Text Revision. Washington, DC: American Psychiatric Association, 2000.
10. McKetin R, McLaren J, Lubman D, Hides L. The prevalence of psychotic symptoms among methamphetamine users. Addiction 2006;101:1473–8.
11. Darke S, Degenhardt L, Mattick R. Mortality amongst illicit drug users: epidemiology, causes and intervention. Cambridge: Cambridge University Press, 2007.
12. Flynn PM, Joe GW, Broome KM, Simpson DD, Brown BS. Recovery from opioid addiction in DATOS. J Subst Abuse Treat 2003;25:177–86.
13. Kaye S, Darke S, Finlay-Jones R. The onset of heroin use and criminal behaviour: does order make a difference? Drug Alcohol Depend 1998;53:79–86.
14. Rogers C. Gang-related homicides in Los Angeles County. J Forensic Sci 1993;38:831–4.
15. Graham K, Leonard KE, Wild TC, Pihl RO, Bois C, Single E. Current directions in understanding and preventing intoxicated aggression. Addiction 1998;93:659–76.
16. Room R, Rossow I. The share of violence attributable to alcohol. J Subst Abuse 2001;6:218–28.
17. Spunt B, Goldstein P, Brownstein H, Fendrich H, Libertym HJ. Drug use by homicide offenders. J Psychoactive Drugs 1995;27:125–34.

18. Spunt B, Goldstein P, Brownstein H, Fendrich H, Langley S. Alcohol and homicide: interviews with prison inmates. J Drug Issues 1994;24:143–63.

19. Cohen JB, Dickow A, Horner K, Zwebern JE, Balabis J, Vandersloot D, et al. Abuse and violence history of men and women in treatment for methamphetamine dependence. Am J Addict 2003;12:377–85.

20. Cottler LB, Compson WM, Mager D, Spitznagel EL, Janca A. Posttraumatic stress disorder among substance abusers from the general population. Am J Psychiatry 1992;149:664–70.

21. Clark HW, Masson CL, Delucchi KL, Hall SM, Sees KL. Violent traumatic events and drug abuse severity. J Subst Abuse Treat 2001;20:121–7.

22. Mills K, Lynskey M, Teesson M, Ross J, Darke S. Post-traumatic stress disorder among people with heroin dependence in the Australian Treatment Outcome Study (ATOS): prevalence and correlates. Drug Alcohol Depend 2005;77:243–9.

23. Galea S, Ahern J, Tardiff K, Leon AC, Vlahov D. Drugs and firearms deaths in New York City, 1990-1998. J Urban Health 2002;79:70–86.

24. Gill JR, Catanese C. Sharp injury fatalities in New York City. J Forensic Sci 2002;47:554–7.

25. Gill JR, Lenz KA, Amolat MJ. Gunshot fatalities in children and adolescents in New York City. J Forensic Sci 2003;48:832–5.

26. Harruff RC, Francisco JT, Elkins SK, Phillips AM, Fernandez GS. Cocaine and homicide in Memphis and Shelby County: an epidemic of violence. J Forensic Sci 1988;33:1231–7.

27. Tardiff K, Marzuk PM, Leon AC, Hirsch CS, Stajic M, Portera L, et al. Cocaine, opiates and ethanol in homicides in New York City. J Forensic Sci 1995;40:387–90.

28. Tardiff K, Wallace Z, Tracy M, Piper TM, Vlahov D, Galea S. Drug and alcohol use as determinants of New York City homicide trends from 1990 to 1998. J Forensic Sci 2005;50:470–4.

29. Australian Institute of Health and Welfare. 2004 national household survey: detailed findings (drug statistics series no. 16). Canberra: Australian Institute of Health and Welfare, 2005.

30. SPSS Inc. SPSS for Windows, 14.0. Chicago: SPSS Inc., 2005.

31. McKetin R, McLaren J, Kelly E. The Sydney methamphetamine market: patterns of supply, use, personal harms and social consequences. National Drug Law Enforcement Research Fund Monograph No. 13. Adelaide: Australasian Centre for Policing Studies, 2005.

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