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Abstract | A large volume of criminal offending involves two or more individuals acting collaboratively. In recent years, much contemporary research on group crime has integrated research on co-offending with the study of criminal networks. However, while this research (mostly from the United States and Canada) is generating significant insights into co-offending, there is a notable absence of research on co-offending and co-offending networks in Australia.

This report presents the findings of a study into co-offending using arrest data from Melbourne, Australia. The study sought to extend previous work on co-offending by analysing the range of crime types committed by individuals and co-offenders across co-offending networks.

Understanding the structure and composition of co-offending networks in Australia

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Introduction

Research on co-offending

The literature on crime and criminal behaviour has long recognised that a large volume of criminal offending involves two or more individuals acting collaboratively. Although the true size and impact of co-offending is still not well known, previous research suggests that up to 35 percent of all crime events involve more than one offender (Carrington 2002; Hodgson 2007; van Mastrigt & Carrington 2014; van Mastrigt & Farrington 2009). Research has further demonstrated that co-offending may lead to an escalation in offending and cause more harms to victims, property and society than solo offending (Carrington 2002; Felson 2003). The study of co-offending patterns is critical to developing a comprehensive understanding of crime statistics, theories of crime and criminal careers; estimation of societal harms; and the impact of policy interventions, including deterrence, incapacitation and rehabilitation (eg McGloin et al. 2008; Morselli, Grund & Boivin 2015; Zimring 1981).

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Research literature acknowledges the importance of studying co-offending. However, only limited research has concentrated on co-offending patterns across different crime types (Morselli, Grund & Boivin 2015), rather than on specific crimes (eg drug crimes; see Iwanski & Frank 2014) or aggregate crime data. Further, no research examines co-offending in Australia. The present study sought to address this critical gap in our knowledge of co-offending patterns in Australia across various crime types.

The network paradigm: Co-offending networks

Co-offending networks are groups of two or more offenders who have committed crimes together (Reiss 1988). Sarnecki (2001, 1990) analysed data on crime events in Sweden to create sociograms (diagrams of actors and the ties connecting them), showing that apparently unrelated crimes could actually be part of larger co-offending networks. Analysing co-offending networks facilitates the investigation of the theoretical assumption that interactions and relations between various actors affect crime (Sarnecki 2001). It also provides insight into offending structures and pathways (McGloin & Nguyen 2014).

Much of the contemporary research that applies a network paradigm to co-offending uses social network analysis (SNA) as an analytic tool (eg Bastomski, Brazil & Papachristos 2017; Bouchard & Konarski 2014; Grund & Morselli 2017; Iwanski & Frank 2014; Lantz & Ruback 2017a, 2017b; Morselli, Grund & Boivin 2015; McGloin & Piquero 2009b; Ouellet, Bouchard & Charette 2019). SNA is an established framework that facilitates the analysis of relationships and interdependencies among groups of individuals (Scott 2012; Wasserman & Faust 1994). It focuses on the relationships or ties between a given set of actors, or nodes, and the implications of these ties for nodes and the network as a whole. Analysing the structural components of the core network can expose the patterns and processes of co-offending and the criminal activity under consideration that may not be easily discovered at first glance (Morselli, Grund & Boivin 2015; Morselli & Roy 2008).

Studies that use SNA typically use cross-sectional analysis to examine co-offending networks at a specific point in time and temporal analyses to examine change in the co-offending network over time (Bouchard & Konarski 2014; Iwanski & Frank 2014; McGloin & Nguyen 2014). Few analyse co-offending across crime types, although market, property and violence-based offences have been found to show significant variation (Morselli, Grund & Boivin 2015). The present study analyses co-offending across four crime categories, as used in previous research on co-offending networks (Morselli, Grund & Boivin 2015):

- violent: crimes against the person (eg assault, murder, attempted murder);
- property: crimes against property (eg malicious damage, break and enter);
- market: crimes committed within illicit markets (eg drug trafficking, prostitution); and
- other: crimes that did not fit within the above three categories (eg traffic violations).

Aims and approach

This study aimed to improve the understanding of co-offending in Australia by analysing the range of crime types committed by individuals and co-offenders across co-offending networks. Particular aims were:

- to examine co-offending networks across single and multiple crime types (including criminal versatility);
- to examine variations in co-offending across specific crime categories (eg non-sexual violent, sexual violent, acquisitive, drug possession, drug trafficking);
- to determine whether there are differences in duration of co-offending, number of co-offenders, extent of co-offending, structure of co-offending networks and age or gender homophily across different categories of crime; and
- to identify the implications of the various co-offending networks for law enforcement practice, within an intelligence-led framework.

Data and method

The project used de-identified arrest data for all offences across a five-year period (2011–2015) for the metropolitan areas of both Melbourne and Sydney. Data were provided by Victoria Police and the NSW Police Force, respectively. SNA was used to explore social structure, criminal versatility, homophily and the duration of co-offending across different crime types. This report presents and discusses the Melbourne data and results.

Data

Data were collected from all Local Government Areas within the two regions that make up the Melbourne metropolitan area (Southern Metro and North-Western Metro). The 'person data' sought for each 'event' listed in the police database were date of arrest, charges, location, date of birth, gender and legal actions. The data were de-identified by Victoria Police before being provided to the researchers. The respective police agencies removed all names from the dataset and replaced them with unique numeric or alphanumeric identifiers. These codes allowed the researchers to identify individuals within the dataset and to track multiple mentions of the same individual in the dataset. 'Event numbers' were used to match individuals to events (arrests). When two or more individuals were involved in the same crime event or events, they were assumed to be co-offenders. The method thus allows for the translation of event or person data into an undirected, weighted co-offending network (explained in more detail below). The weight or strength of ties between co-offenders is dependent on the number of times they are observed to co-offend together; the more a pair of offenders co-offend, the stronger their co-offending tie.

Data analysis

We performed four main data cleaning procedures to prepare the data for analyses. Firstly, we removed offenders who had erroneous year of birth entries (eg two dates of births in the dataset which were more than two years apart; inexplicably low or high birth dates). Secondly, where individuals faced multiple charges for the same incident (identified from the date of that incident and event number), we removed the less serious offences. Thus, for incidents where individuals were charged with more than one offence, only the most serious offence was retained. Seriousness was determined using the National Offence Index (2018), which provides seriousness scores for all crimes listed in the Australian and New Zealand Standard Offence Classification (ANZSOC) codes (ABS 2011). Thirdly, for incidents with multiple charge dates associated with them, meaning that there was more than one offender, and the offenders were charged on different dates, we retained the earliest charge date. Finally, consistently with previous research that sets a threshold for co-offending group size (eg Grund & Morselli 2017), we removed events involving 12 or more co-offenders.

All offence types were classified into one of 16 ANZSOC divisions, which we call crime types, listed in Table 1.

Table 1: Crime types (based on ANZSOC Classification)

1	Homicide
2	Acts intended to cause injury (AICI)
3	Sexual assault and related offences
4	Dangerous or negligent acts endangering persons
5	Abduction, harassment and other offences against the person
6	Robbery, extortion and related offences
7	Unlawful entry with intent/burglary, break and enter
8	Theft and related offences
9	Fraud, deception and related offences
10	Illicit drug offences
11	Prohibited and regulated weapons and explosives offences
12	Property damage and environmental pollution
13	Public order offences
14	Traffic and vehicle regulatory offences
15	Offences against government procedures, government security and government Operations (OAGP)
16	Miscellaneous offences

The 16 divisions were further sorted into the four crime categories mentioned earlier: violent—crimes against the person; property—crimes against property; market—crimes committed within illicit markets; and other—crimes that did not fit within the above three categories. These four crime categories form the basis of our analysis.

All data were analysed using the R software package with the SNA module (R Core Team 2012). This software enables the measurement of a number of SNA metrics, including network density, degree centrality of actors, betweenness centrality of actors, network diameter, the size and number of network components, and assortativity based on gender, degree and age (see Borgatti, Everett & Johnson 2013).

Definitions:

- *Network density* is a measure of the extent of interconnectedness of the network. Formally, it is the proportion of potential ties between all network actors that are actually formed in the network.
- *Degree centrality* is a measure of the number of other network actors to which any one actor is linked. It is generally considered to be a measure of the power or influence of network actors.
- *Betweenness centrality* is a measure of the extent to which an actor is strategically positioned on the shortest paths between all other actors in the network. High betweenness centrality actors are considered to be brokers.
- *Network diameter* is a measure of the shortest path between the two most distant nodes in the network. It can be considered a proxy for how long it might take information to get from one end of the network to the other.
- A *network component* is a complete, connected set of actors, where no actor is disconnected. A network may be made up of one or more components.
- *Assortativity* is a network measure of 'homophily', the notion that 'birds of a feather flock together'. It is a measure of the extent to which actors with similar attributes (eg same age, same gender, same degree score) tend to be connected.

Data preparation and extraction was conducted in two key stages (following previous work by Brantingham et al. 2011). Every tie (or edge) in the network either links an offender to an event, or links two offenders with one another. In the latter case, it shows that two offenders have committed a crime or multiple crimes together. Edges were given a weight (or strength) according to the number of offences each pair of offenders committed together. The strength of the link between any two offenders reflects the number of offences in which they were both involved—the number of times they have offended together—and edges also represent the type of offence committed by the pair. Each actor in the network had attribute information for date of birth, gender and categories of offences in which they have participated.

Once we had determined who was involved in particular crime events, we constructed a co-offending network matrix from two-mode data, where offenders are linked according to co-participation in the same crime event. These two-mode networks were then converted into a one-mode network, with the individuals arrested for involvement in the same incident being assumed to have a co-offending relationship. The network only includes individuals who had at least one co-offence. The co-offending network was then further classified by offence type. Only violent, property and market offences were included (all 'other' offence types, such as traffic offences, were excluded).

Finally, we classified offenders into categories, using the classification scheme developed by Morselli, Grund and Boivin (2015): core, periphery and mass. Core offenders are those with the top five percent of ties. The periphery includes all offenders who are not in the core but have at least one co-offence with a member of the core. Mass refers to all offenders who are not in the core and did not co-offend with core members.

Results

After cleaning the data and removing all 'other' offences from the data set, we had 102,261 offenders, of whom 78,399 (77%) were male and 23,862 (23%) were female.

Table 2 shows that the sample committed a total of 216,211 offences across the entire time period; 12,329 (6%) of these involved co-offending. The largest proportion of co-offending occurred for market-based offences and property offences (both 7%), followed by violent offences (4%). The table also demonstrates that the majority of offending involved property crime (46%), followed by violent crime (31%) and market-based crime (23%).

Table 2: Proportion of offences that involve co-offending

	Offences (*n*)	Co-offending (*n*)	%
Violent	97,272	3,830	3.9
Property	80,327	5,719	7.1
Market	38,612	2,780	7.1
Total	216,211	12,329	5.7

Table 3 shows that 25 percent of offenders aged 18–25 were co-offenders, with the proportion declining as age increased; 14 percent of offenders aged 26 and over committed crimes with one or more co-offenders.

Table 3: Number of offenders and co-offenders by age

Age	Offenders (*n*)	Co-offenders (*n*)	Co-offenders (%)
18–25	32,093	8,017	24.9
26–35	30,193	5,216	17.2
36–45	22,397	2,829	12.6
46–89	17,578	1,551	8.8
Total	102,261	17,613	17.2

Overall, offenders who committed crimes in which they co-offended with others comprised 17 percent of the total number of offenders.

Table 4 shows that property and market offences overall had higher rates of co-offending (19% and 18% respectively) than violent offending.

Table 4: Number of offenders by offence types

Offence type	Offenders *n* (%)	Co-offenders *n* (%)
Violent	60,174 (47.3)	6,839 (11.4)
Property	40,863 (32.1)	7,572 (18.5)
Market	26,156 (20.6)	4,781 (18.3)

Tables 5 and 6 show the proportion of offenders within each offence type who had co-offenders. Note that such co-offending might occur across multiple crime types. For example, an offender who commits a robbery/extortion offence might also co-offend with others in theft and illicit drug offences. The individual would be classified as a co-offender for the purposes of the above calculations.

Forty-three percent of offenders who engage in robbery and extortion offences engage in co-offending. In contrast, six percent of offenders charged with sexual assault engaged in any co-offending. The results suggest that estimates of the extent of co-offending that aggregate across crime types will miss the nuances of co-offending across crime types and miss the higher prevalence of co-offending among some groups of offenders.

Table 5: Offenders who engage in any co-offending as proportion of total by ANZSOC codes[a]

Offence type	Proportion of total who were co-offenders (%)
Robbery, extortion	43
Unlawful entry	35
Homicide	28
Theft and related	18
Illicit drug offences	18
Fraud, deception	17
Acts intended to cause injury	12
Public order offences	9
Prohibited and regulated firearms	8
Property damage	8
Dangerous or negligent acts	7
Sexual assault	6
Abduction, harassment	6
Offences against government	3

a: Traffic and vehicular offences removed

Table 6: Proportion of offences that involve co-offending

	Proportion of total who were co-offenders (%)
Violent	11
Property	26
Market	18
Other	10

Figure 1 demonstrates that, across all offence types, most offences (around 80%) involved only two co-offenders. Around 10 percent of offences involved three offenders. Crimes involving four or more co-offenders were rare.

Figure 1: Number of co-offenders per offence (%)

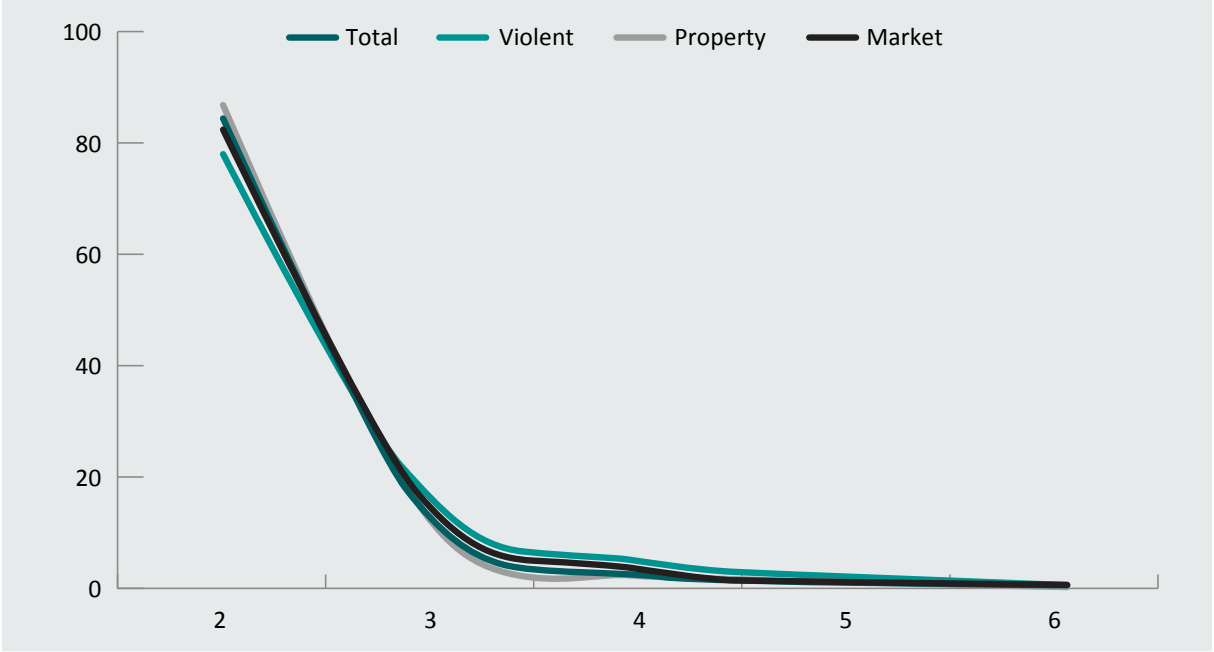


Table 7 shows the network position for co-offenders only. Co-offenders in the core committed the largest average number of offences (6.64), followed by those in the periphery (5.88) and the mass (3.65). Violent and property co-offenders made up the largest number of co-offenders in each of the core, periphery and mass. Violent co-offenders were just under half (49%) of co-offenders in the core. For co-offenders in the core, the average number of unique co-offenders was five. In the periphery, the average was two, with an average of one for the mass. This finding suggests that offenders in the core have a larger network of potential co-offenders.

Table 7: Co-offender network

	Core	Periphery	Mass
Male (%)	84	74	75
Age (%)			
18–25	53	51	44
26–35	29	30	3
36–45	14	14	16
46–89	4	5	10
Offences (*n*)	6.64	5.88	3.65
Offence type (%)			
Violent	49	37	38
Property	31	40	37
Market	20	23	25
Unique co-offenders (*n*)	5.07	2.02	1.34

Table 8 shows:

- There is a larger network of co-offenders who co-offended with property offenders (7,572) compared with violent (6,839) and market offences (4,781).
- There is a longer distance for network, and clustering is lower, for property offences. Clustering is the extent to which network actors are interconnected. High clustering indicates that many of the actors are connected with each other. Low clustering suggests that relatively few actors are connected.
- All offence types had a small component size (2–3 actors on average).
- Degree assortativity was very strong across all offence types, indicating that offenders tend to co-offend with others who have the same number of unique co-offenders. (We note that the interpretation of degree assortativity is biased by the transformation of a two-mode network into a one-mode network.)
- Gender assortativity is moderate for violent and property networks, suggesting that co-offenders with at least one violent offence tend to co-offend with those of the same gender. It was, however, negative for market-based offences, denoting a weak tendency for market offenders to co-offend with either male or female co-offenders.

Age group assortativity is strong across all offence types, meaning that there is a strong tendency to co-offend with others in the same age group.

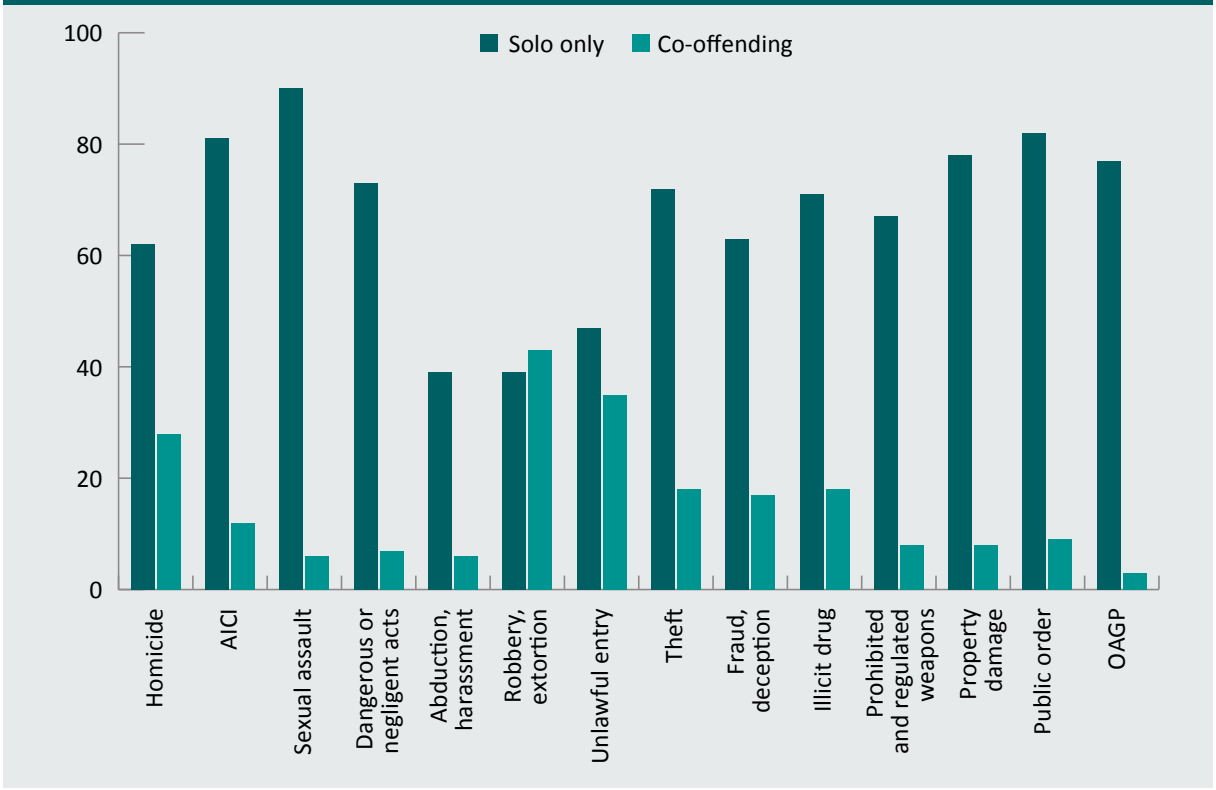
Table 8: Network (co-offenders only)

	Total	Violent	Property	Market
Nodes (*n*)	21,034	6,839	7,572	4,781
Edges (*n*)	18,011	5,733	5,608	3,555
Density	0.0003	0.001	0.001	0.002
Average distance	21.1	1.34	3.32	1.24
Diameter	58	9	14	6
Cluster coefficient	0.65	0.88	0.63	0.83
Degree centrality	0.001	0.001	0.002	0.001
Betweenness centrality	0.002	0.00001	0.001	0
Number of components	7,195	2,724	2,936	1,972
Mean size components	80.03	2.5	2.58	2.42
Degree assortativity	0.65	0.89	0.65	0.8
Gender assortativity	0.13	0.22	0.16	–0.02
Age group assortativity	0.48	0.45	0.51	0.49

Note: For a description of these metrics, see Borgatti, Everett & Johnson (2013)

Figure 2 shows the proportion of offenders who committed solo offences only—that is, offenders who never co-offended over the time period. Of offenders charged with homicide, 62 percent were never charged with an offence involving a co-offender over the time period. Abduction, robbery and unlawful entry were least likely (less than half) to involve solo offending only. Co-offending was highest among robbery, extortion and related offences and unlawful entry or break and enter offences. Co-offending was next highest in homicide and theft, fraud and deception offences and illicit drug offences.

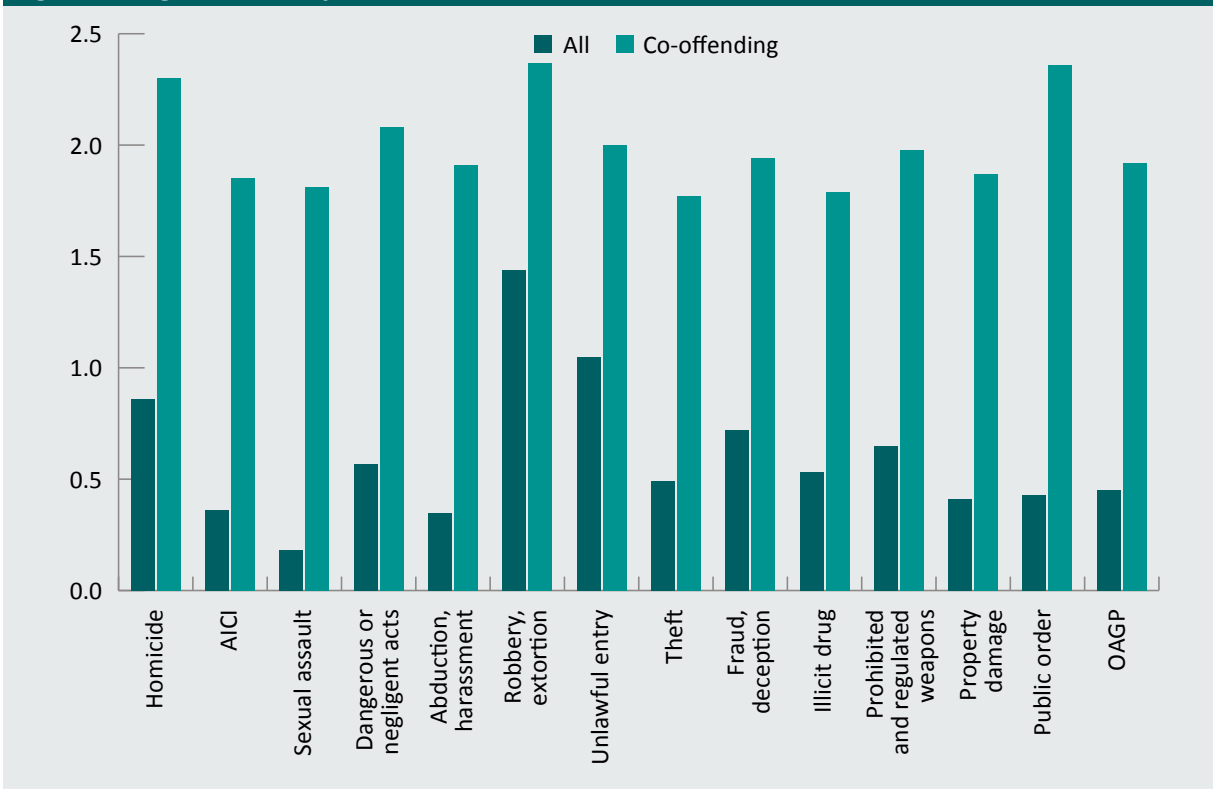
Figure 2: Solo only and co-offending by offence type (%)



Note: AICI=acts intended to cause injury; OAGP=offences against government procedures, government security and government operations

Figure 3 shows degree centrality for co-offenders by type of offence. It displays the average number of co-offenders for offenders charged with a particular crime type, for all offenders and all co-offenders. Overall, the results were fairly uniform across offence types (range=1.79–2.37). Offenders charged with homicide, dangerous or negligent acts, robbery, unlawful entry and public order offences were highest by degree centrality, with an average degree of 2 or above. Over the five-year period, these offenders co-offended with at least two others.

Figure 3: Degree centrality

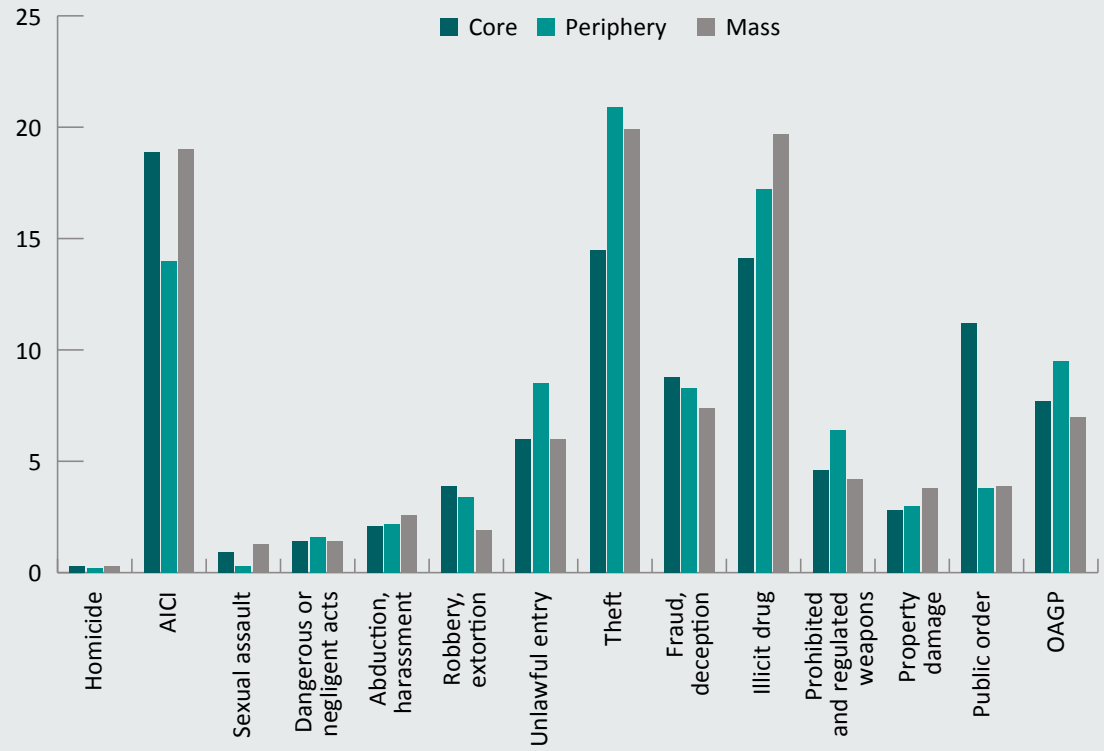


Note: AICI=acts intended to cause injury; OAGP=offences against government procedures, government security and government operations

Figure 4 shows that the core, periphery and mass are dominated by acts intended to cause injury, theft and illicit drug offences. Public order offences are more prominent in core compared with periphery and mass, while the reverse is somewhat true for theft and related offences. OAGPs are fairly evenly represented in the core, periphery and mass.

The following figures provide a visual map of all offences in the dataset (Figure 5), followed by maps for each crime type: violent offences (Figure 6); property offences (Figure 7); and market offences (Figure 8). Node size represents the number of offences, node colour the offender's gender, and edge labels the number of co-arrests between offenders. The network maps are provided to give an overall 'bird's eye view' of the structure of co-offending networks in the city.

Figure 4: Network structure by offence type (%)



Note: AICI=acts intended to cause injury; OAGP=offences against government procedures, government security and government operations

Figure 5: Network map showing all offences

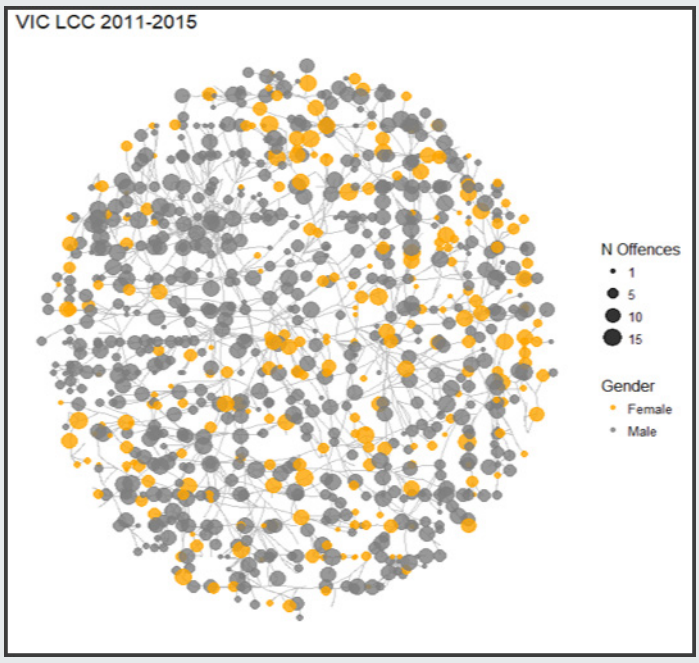


Figure 6: Network map showing violent offences

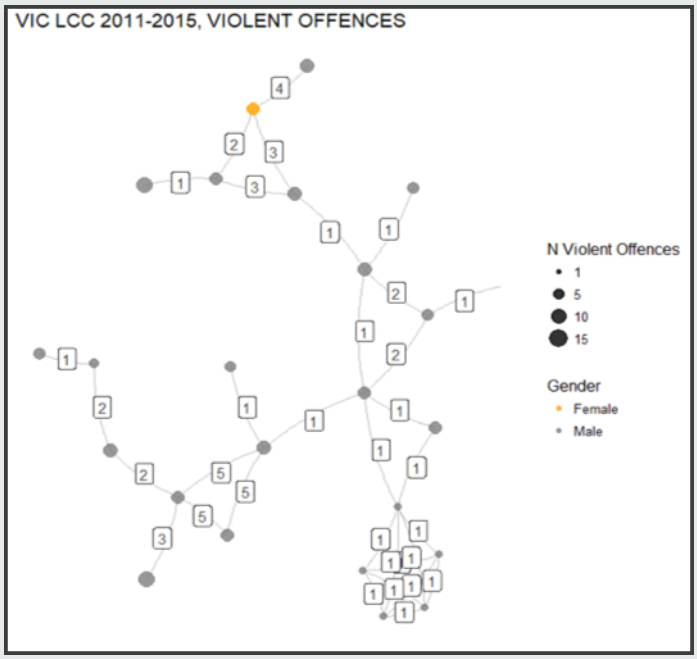


Figure 7: Network map showing property offences

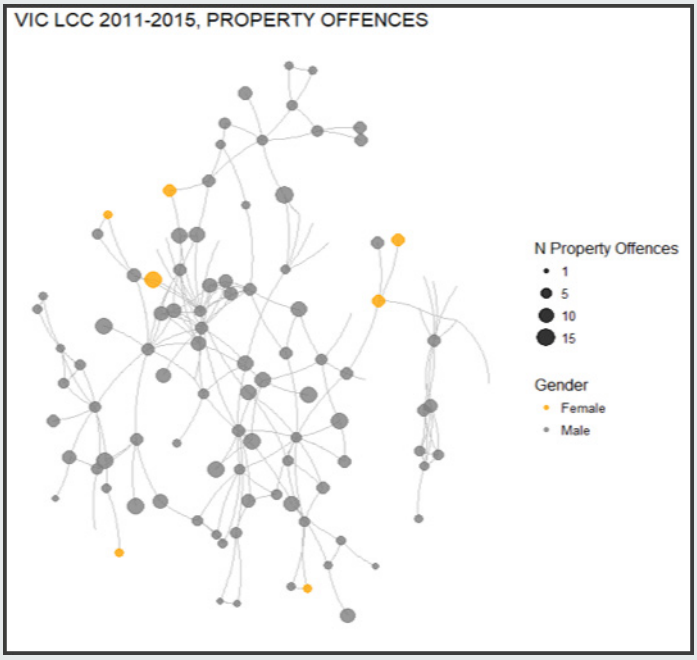
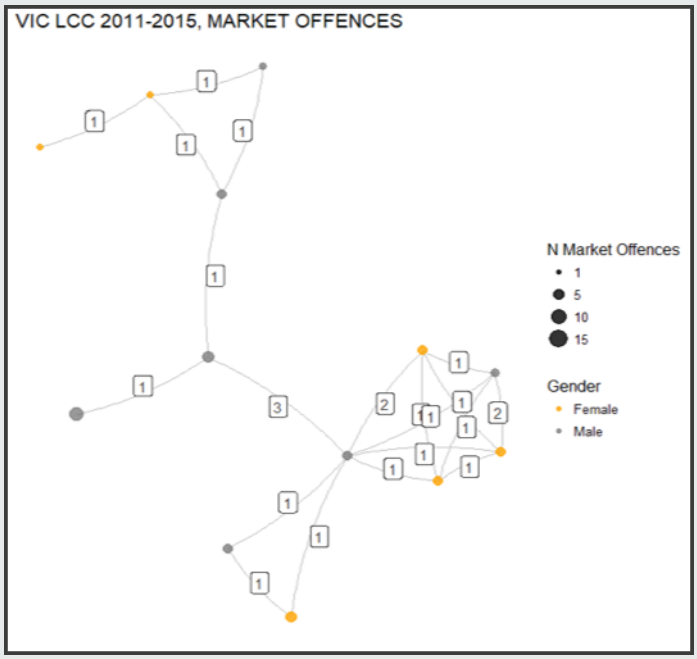


Figure 8: Network map showing market-based offences



Discussion and conclusion

Co-offending prevalence

Table 9 shows that 17 percent of offenders in the Melbourne metropolitan area engaged in any co-offending, and six percent of offences involved co-offending. In the crime categories, seven percent of market and property offences, but only four percent of violent offences, involved co-offending. Of property offenders, 19 percent were co-offenders; of market offenders, 18 percent were co-offenders; and of violent offenders, 11 percent were co-offenders. Of offence types, more than 25 percent of the following offences involved co-offending: robbery and extortion (43%), unlawful entry (35%) and homicide (20%). In terms of the overall network of co-offenders, the majority of offences in the core were violent offences (49%), followed by property (31%) and market offences (20%).

Overall, rates of co-offending were low—somewhat lower than estimates in previous studies (eg Andresen & Felson 2012; Morselli, Grund & Boivin 2015). However, more recent studies using large sample sizes, as the current study did, have produced divergent estimates of the prevalence of co-offending (eg van Mastrigt & Farrington 2009), as discussed in Andresen and Felson (2012).

This is the first study of co-offending using Australian data. Although we did not expect differences in the nature and prevalence of co-offending across countries such as Australia, the United Kingdom, United States and Canada, it is possible that differences in data collection, coding and management account for many of the variations measured by researchers in different jurisdictions.

Table 9: Summary of results	
Proportion of co-offenders	17.2
Property (% co-offenders)	18.5
Market (% co-offenders)	18.3
Violent (% co-offenders)	11.4
Offences (% co-offenders)	5.7

Impact of co-offending

Despite the small prevalence rates—which we identified as likely to partly reflect the nature of the data sample—the study of co-offenders is important because they place a burden on resources in the criminal justice system. Co-offending has been shown to lead to increased recidivism and to trend towards more serious offences for those who co-offend (Carrington 2002; Felson 2003; Lantz 2018, 2019b; Lantz & Hutchison 2015; McGloin & Piquero 2009a; Tillyer & Tillyer 2019). Further, for each offence involving co-offenders, the costs to the criminal justice system are amplified, compared with solo offending. Although the great majority of co-offending involves no more than two offenders, co-offending also occurs with larger numbers of co-offenders (see Figure 1).

Crime types

The current study reinforces earlier research (eg Lantz 2019a; Terranova, Vandiver & Stafford 2019; van Mastrigt & Farrington 2009) suggesting that co-offending should be studied in disaggregated form rather than as a total across all crime types. Some crimes, mainly acquisitive crimes such as burglary and robbery, are more strongly associated with co-offending; this could skew results if aggregates are used. This could, in turn, lead to misdirected law enforcement measures.

Research results suggest that an underlying trait such as low self-control or impulsivity is unlikely to account completely for co-offending across crime types. If that were the case, we would expect co-offending prevalence to be more or less evenly distributed across crime types, rather than showing different prevalence rates across crime types and categories. Rather, our results across different crime types suggest two primary mechanisms that may account for co-offending. Firstly, for some crime types, co-offending may be perceived by offenders as easier, less risky and more profitable than solo offending. Secondly, offenders may gain some other socially mediated benefit from co-offending: shared responsibility for criminal behaviour, diminished feelings of personal responsibility or increased camaraderie and bonding. These socially mediated effects may be stronger for some types of crime, such as robbery and burglary, than for other types of crime, such as interpersonal violence (including sexual assault).

Networks of co-offenders

Our results suggest that the study of co-offending networks offers a more in-depth view of co-offending. Most individuals in the core of the co-offending networks had committed a violent crime. Such individuals made up approximately half of offenders. This finding suggests that individuals who had committed violent offences had a larger personal network of co-offenders in the network. Such individuals may have easier access to a range of potential co-offenders, presumably across crime types.

Degree assortativity was also strong in the co-offending networks, suggesting that offenders tend to offend with others who have a similar number of unique co-offenders. Age assortativity was also strong, supporting other research (Budd, Sharp & Mayhew 2005; Reiss & Farrington 1991; Sarnecki 2001; Warr 1996) showing that offenders tend to co-offend with others of approximately the same age or age group. Findings for gender assortativity suggest that, when committing violent offences, offenders tend to co-offend with others of the same gender. However, results suggest that there is a tendency for market-based offences to be committed by mixed-gender groups (males and females co-offending).

Policy implications

The findings of this study offer a number of significant benefits for law enforcement agencies and policymakers.

Our study confirms the finding of previous research, that studying co-offending is critical for understanding crime and determining prevention and intervention strategies. Reasons include:

- We cannot accurately calculate the incidence of crime and its impact without considering co-offending. Harms to victims are not always proportional, because some crimes involve more than one offender.
- The financial burden on the criminal justice system is greater when crimes involve more than one offender, intercepted by police and moving through the courts and correctional processes.
- Co-offending may lead to longer criminal careers, compared with solo offending.

Our results suggest that police agencies should collect data on co-offending as a matter of course to inform their understanding of crime patterns within their jurisdiction. Such data collection and analysis should be conducted at the level of crime type, in order to facilitate a clear picture of co-offending versus solo offending and to assist with the implementation of responsive policing strategies.

Limitations

The study suffered from a number of limitations. The first is the issue of data quality; the data were used to connect offenders with particular offences, and we needed to make assumptions about which offenders co-participated in offences. In doing so, we may have unwittingly underestimated or overestimated the extent of co-offending. We selected a particular geographical area as a boundary for data collection, so it is highly likely that at least some co-offending was not captured because it took place outside our artificial boundaries (eg in a neighbouring local area command). We collected data within a set timeframe of five years, and extending this timeframe (eg to 10 years) would probably have encompassed significantly more co-offending. We used particular definitions and operationalisations of crime types and classifications, but a different set of results may have emerged from alternative methods of aggregating and classifying crime types. Generalisability to other cities, regions and countries is not known. Because we examined multiple crime types, offenders could be involved in co-offending with respect to more than one type of crime over time; this means that we did not examine co-offending that occurred for specific offence types. Finally, we used crime seriousness definitions to determine the most serious offence in order to classify offenders to a crime type; although we used a dominant method for doing so, different results may have emerged through an alternative methodology.

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