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Assessing the risk of repeat intimate partner assault

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Aim: *To identify factors associated with the risk of experiencing repeat intimate partner assault.*

Method: *A subset of 336 individuals who reported experiencing intimate partner violence (IPV) in the 12 months prior to participating in the ABS Personal Safety Survey 2016 was identified, 145 (43.2%) of whom experienced repeat victimisation involving assault. Population-weighted logistic regression models were used to estimate the likelihood of experiencing repeat IPV involving assault in the 12 months prior to survey response.*

Results: *The best population-weighted logistic regression model indicated that the following factors significantly correlate with experience of repeat IPV assault: experience of emotional abuse in the most recent 12 months, socioeconomic disadvantage and remoteness of a person's area of residence, low educational attainment and disability status. This model correctly classified 69.3 per cent of cases and had acceptable levels of discrimination (AUC=.760).*

Conclusion: *Victim experience of emotional abuse and sociodemographic factors are potentially useful factors for inclusion in risk assessment tools to identify victims at risk of repeat IPV.*

Keywords: *Intimate partner violence, risk assessment, logistic regression*

INTRODUCTION

Domestic violence is an area of increasing policy focus in NSW. Recent estimates using survey data suggest that the rate of physical domestic and family violence victimisation in NSW is 525 victims per 100,000 people (Freeman, 2018). Furthermore, the Australian Bureau of Statistics (2018a) estimates that roughly 54.5 per cent of female and 64.9 per cent of male victims of IPV by their current partner experienced more than one violent incident. Reducing repeat IPV victimisation can have a major impact on the reported and unreported rate of DV.

A critical step in designing strategies to reduce repeat victimisation is risk assessment. IPV risk assessment tools have been developed and are currently in use in every state in Australia, with the exception of Queensland and the ACT (McCulloch, Maher, Fitz-Gibbon, Segrave, & Roffee, 2016). They are typically used as a triage tool to direct support services or programs that have limited capacity to those who are at greatest risk of further victimisation. In the Northern Territory, Victoria and Western Australia, actuarial tools are used alongside professional judgement to identify high risk cases (McCulloch et al., 2016). In general, methods employed to assess risk vary, as does their accuracy in prediction. Some are based on unstructured clinical judgement; others use statistical algorithms to estimate risk from administrative/survey data; some use a combination of both these techniques (Andrews & Bonta, 2006).

In NSW, the Domestic Violence Safety Action Tool (DVSAT) (NSW Government, 2015) is the risk assessment instrument currently being used by police. The DVSAT is a key component of the broader Safer Pathway initiative introduced to reduce domestic violence. Police administer the DVSAT to victims of domestic violence (who report to police) to assess the risk of serious repeat victimisation. Those deemed to be at serious risk

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are referred to Safety Action Meetings (SAMs). SAMs involve multiple government agencies working together to develop and implement a Safety Action Plan to reduce the victim's risk of further victimisation (see NSW Government, 2014, for further details).

The DVSAT is a two-part questionnaire. Part A (the risk identification checklist) consists of 25 questions asking about the victim's prior experience of violence, the relationship between the victim and the perpetrator (including controlling behaviour experienced in the relationship), the background of the perpetrator, whether there are children in the relationship and sexual assault experience in the relationship. This section is used only for IPV victims. Part B is applicable to both non-IPV and IPV victims and contains five questions that the attending police officer answers, based on their subjective assessment of the victim's level of fear, reasons for being fearful, whether children appear to be at risk and whether there are any other risk factors present. The test administrator is also able to incorporate victims' own perceptions of threats to their safety in this section. This assessment is based on information gathered from the victim, and the knowledge, skills and experience of the officer completing the DVSAT.

The DVSAT classifies victims into one of two categories:

- 'At threat' which means there is evidence of a threat to a victim's life, health or safety due to domestic violence
- 'At serious threat' which means there is evidence of a serious threat to a victim's life, health or safety due to domestic violence, and urgent action is necessary to prevent or lessen this threat.

The threshold for an assessment of 'at serious threat' is 12 or more 'yes' answers to the 25 questions contained in Part A of the DVSAT or the professional judgement of the attending officer as recorded in Part B.[1]

Ringland (2018) examined the accuracy of the DVSAT in predicting repeat victimisation by an intimate partner using data from 24,462 victims of IPV who had been administered the DVSAT over the period 1 January 2016 to 30 June 2016. Using logistic regression, Ringland found that answering 'yes' to 12 or more items on the DVSAT did not discriminate well between those who experienced another victimisation episode within 12 months and those who did not. The most common measure of prediction accuracy is the AUC (Area Under the Curve) which varies between .5 (prediction accuracy no better than chance) and 1.0 (perfect prediction). The AUC for answering 'yes' to 12 or more items on the DVSAT was just .517. Broadening the definition to include any classification of 'at serious threat' (based on Part A, Part B or prior victimisation) only marginally improved discrimination (AUC=.572). Furthermore, while Ringland found that many individual DVSAT items were associated with repeat victimisation, some were not and others were inversely associated with repeat victimisation (i.e. a predicted lower risk of repeat victimisation when they were expected to predict a higher risk of victimisation). These findings are concerning as triaging victims based on a tool with a high level of misclassification may lead to many victims not receiving the intensive support and services they require.

PRIOR RESEARCH

Prior to the development of structured risk assessment tools, unstructured clinical judgement was used to assess risk in criminal justice settings. An advantage of using clinical judgement is that the assessor possesses a degree of training and expertise in psychology or a relevant field and is well-placed to examine psychological and other contributory factors. Over time however, the reliance solely on professional judgment in risk assessment fell out of fashion. Unstructured clinical judgement has been criticised for its lack of uniformity, transparency and accountability. Grove and Meehl (1994), for example, maintain that being risk assessed by a single decision-maker with no guidelines or constraints results in widely differing outcomes based on the assessor. Since then, efforts have been made to develop actuarial tools which classify offenders or victims into groups based on a set number of questions or criteria. While addressing the shortcomings of unstructured clinical judgement, these have in turn been criticised as being too limited to encapsulate situational factors and consequently are imprecise (Hart & Cooke, 2013). The most common tools currently used in most jurisdictions are those which combine an actuarial assessment with an element of expert judgement (Nicholls, Pritchard, Reeves, & Hilterman, 2013).

A number of IPV risk assessment tools have been developed and are available in Australia and internationally but most of these tools have been developed to predict the risk of re-offending rather than re-victimisation. For this reason, these tools largely focus on perpetrator characteristics and behaviour, though some also incorporate victim perspectives on perpetrator behaviour. The best validated tool is the Ontario Domestic Assault Risk Assessment (ODARA) (Hilton, Harris, & Rice, 2010). It includes factors relating to perpetrator substance abuse and criminal history, victim perceptions of future violence and situational factors. An enhanced version of this scale, the Domestic Violence Risk Appraisal Guide (DVRAG) (Hilton, Harris, Rice, Houghton, & Eke, 2008) also includes an additional measure of perpetrator psychopathy. A review by Messing and Thaller (2013), which aggregated the results from 25 studies, found that the ODARA had higher predictive accuracy than other standard tools used to assess risk of intimate partner violence (see also Nicholls, Pritchard, Reeves, & Hilterman, 2013), but noted that

none of the tools they reviewed achieved an acceptable level of discrimination (i.e. an AUC exceeding .7) when averaged across studies reviewed. The Domestic Violence Screening Instrument – Revised (DVSI-R) (Williams & Houghton, 2004) appears to be the next best performing tool, achieving AUCs between .61 and .73 in four studies examined by Nicholls, Pritchard, Reeves, and Hilterman (2013) and an average AUC of .618 in three studies examined by Messing and Thaller (2013), but is also below the threshold for acceptable levels of discrimination.

Only one review has considered the extent to which available IPV risk assessment tools are valid to use in the context of repeat IPV victimisation. Roehl, O'Sullivan, Webster, and Campbell (2005) examined the extent to which the Danger Assessment (DA) (Campbell, 1995), DV-MOSAIC (De Becker & Associates, 2000), DVSI and the Kingston Screening Instrument for Domestic Violence (K-SID) (Gelles, 1998) successfully predict repeat IPV victimisation, as well as the predictive validity of victims' own assessment of future harms. The authors administered the four screening tools to 1,307 domestic violence victims in New York City and Los Angeles. The victims were followed up six months to a year later to measure re-victimisation. The Danger Assessment (DA) performed the best of the four risk assessment tools evaluated (AUC=.635 for any re-assault, AUC=.670 for severe re-assault). The three other tools assessed performed no better than chance, achieving statistically insignificant AUCs ranging from .5-.6. Victims' perceptions of risk performed only slightly better than chance in predicting re-assault (AUC=.599) and severe re-assault (AUC=.619). Accounting for protective actions taken by victims after the first incident improved all tools' predictive capabilities, but still none achieved acceptable levels of discrimination between repeat and non-repeat victims.

In addition to Ringland (2018), two other studies have been undertaken in Australia to evaluate the predictive ability of established risk assessment tools. Both of these studies measured the risk of recidivism rather than repeat victimisation. Lauria, McEwan, Luebbers, Simmons, and Ogloff (2017) assessed the ODARA against 200 eligible IPV cases in Victoria (male-to-female intimate partner violence with a history of assault and cohabitation) and found that it achieved AUCs of .68 for physical assault recidivism and .72 for non-physical abuse recidivism. Using a random sample of 1,406 family violence offenders drawn from the Tasmania police database, Mason and Julian (2009) examined the extent to which the RAST (Tasmania's Risk Assessment Screening Tool) predicted re-offending. While the overall RAST score yielded a poor AUC of .602, if only statistically significant RAST items (breach of previous order, access to firearms, past threats, jealousy and depression) were retained in the logistic regression model, an acceptable AUC of .726 was achieved.

THE CURRENT STUDY

A number of risk assessment tools have been developed to estimate the likelihood of family violence and intimate partner violence re-offending, mostly encompassing perpetrator characteristics, criminal history, IPV behaviours and situational factors. Few existing instruments or tools include risk and vulnerability factors related to victims. Validation studies suggest that the best of these tools can reach moderate levels of predictive accuracy (AUCs in the range of .70-.75), but most commonly demonstrate low levels of accuracy (.60-.65). While two studies have examined the classification ability of established tools of repeat IPV risk on subsequent IPV offending, only one study has tested these established tools in predicting the risk of future re-victimisation in an Australian context. The current study addresses this limitation of prior research by analysing factors which are significantly associated with the risk of repeated IPV involving assault and to assess the ability of these factors to accurately classify those who experience repeat IPV and those who do not.

METHOD

DATA SOURCES

The sample used in this study was 336 respondents to the 2016 ABS Personal Safety Survey (PSS) (ABS, 2018c) who had experienced an incident of intimate partner violence by a current or previous partner within the 12 months prior to data collection. The 2016 PSS was undertaken between 6 November 2016 to 3 June 2017 and collected information from men and women aged 18 years and older about the nature and extent of violence they experienced since the age of 15, including detailed information about men's and women's experience of current and previous partner violence and emotional abuse. Only one person in a household was selected to respond to the survey. The method of collection was through a face-to-face interview, although respondents were also given the option of confidentially entering their information into a laptop pre-loaded with a response interface (ABS, 2018b). Where a respondent had experienced violence by a current partner and/or previous partner they were asked further questions about what happened during the relationship. This information was collected separately for current partner violence and previous partner violence: if someone had experienced violence by more than one previous partner, the information was collected only in relation to the previous partner who most recently committed violence against them. It should be noted that the ABS classifies violence in the PSS as any incident involving the occurrence, attempt or threat of either physical or sexual assault experienced by a person since the age of 15, where 'physical violence' includes physical assault and/or physical threat, and 'sexual violence' includes sexual assault and/or

sexual threat, and classifies a partner as a person the respondent currently lives with, or has lived with at some point, in a married or de facto relationship (ABS, 2018a).

The PSS data involves six separate datasets, termed 'levels', which contain different types of information (further detailed in ABS, 2018c, in the 'File Structure and Content' section):

- **Household level:** contains compositional and geographic information about the respondent's household and household income at the time of the survey;
- **Person level:** contains socio-demographic information about the respondent and information about a person's current partner who they are living with at the time of survey;
- **Most recent incident level:** contains detailed information about the characteristics of the most recent incident (MRI) of violence which occurred in the 10 years prior to the survey and since the age of 15 experienced by the respondent. Information about the MRI was collected for each of the following types of violence: sexual assault by a male, sexual assault by a female, sexual threat by a male, sexual threat by a female, physical assault by a male, physical assault by a female, physical threat by a male, physical threat by a female;
- **Violence prevalence level:** contains information on different types of violence experienced by a respondent since the age of 15. The information recorded includes the type of violence, the perpetrator of the violence and when the most recent incident occurred in relation to the time of survey collection for the following six perpetrator types: current partner, previous partner, boyfriend/girlfriend/date, ex-boyfriend/ex-girlfriend, other known person, and stranger. The following types of violence were recorded: physical assault, physical threat, physical violence, sexual assault, sexual threat, sexual violence, assault, threat and violence. In this file, the timeframe of the most recent incident is recorded in a variable with the following categories:
  a) Less than 12 months ago;
  b) 1 to less than 2 years ago;
  c) 2 to less than 3 years ago;
  d) 3 to less than 5 years ago;
  e) 5 to less than 10 years ago;
  f) 10 to less than 20 years ago;
  g) 20 years ago or more; or
  h) Not known.
- **Partner violence level:** contains detailed information about men's and women's experience of violence (physical or sexual violence experienced since the age of 15) by their current partner and/or their most recently violent previous partner. It presents information about characteristics of the violence and the relationship, such as the duration of the relationship, periods of separation, how often violence was experienced, whether anyone was told about the violence etc., in order to gain greater insight into their experience; and
- **Partner emotional abuse level:** contains information about experiences of emotional abuse by a current and/or previous partner since the age of 15.

Population weights

Respondents to the PSS, as in any other survey, have unequal probabilities of being sampled. Hence, sample estimates obtained from unweighted analysis of this data may differ from estimates obtained from population data because the sample may not be representative of the underlying distribution of people in the population. For this reason the PSS data contain both frequency weights at a person level and replicate weights derived using the delete-a-group jackknife method.[2] Both these weights were retained in the dataset and implemented in all statistical analyses by using the *svy jackknife* setting and prefix in Stata 15 (MP) in order to obtain weighted population estimates and standard errors calculated over 60 replications. The ABS cautions that the assigned weights at each level could produce a total in excess of the true total population if multiple records for each person on any level other than the Household and Person levels are summed. Therefore, we merged data from different levels using only one record per person per data level to ensure that the dataset did not contain repeated weights for the same person.

Thus selection rules were applied to each level of the PSS data to produce the final analysis dataset, where each observation related to a person and one perpetrator of partner violence. First, people who had an incident of partner violence in the last 12 months (n=336) were selected.[3] Then the perpetrator of the most recent incident of partner violence in the last 12 months (hereafter referred to as the index partner) was identified using the

Table 1. Selection rules for 2016 PSS data levels

Level	Selection rule(s)
Household	The index person from the household is an observation
Person	The index person from the household is an observation
Partner violence	Selected all observations of partner violence relating to index violent partner (either current or previous partner)
Violence prevalence	Used to identify index violent partner for person
Partner emotional abuse	Selected any observation which pertained to an experience in the last 12 months (no further aggregation required)

timeframes in the violence prevalence dataset.[4] If the respondent experienced both current and previous partner violence in the past 12 months, the current partner was chosen. This dataset was then linked to the person and household-level files. The emotional abuse level data for those who had experienced emotional abuse within the last 12 months was then linked. Note that if index perpetrator of emotional abuse was a previous partner at the emotional abuse level, they may not be the same previous partner who committed the partner violence; thus we restrict the linkage of emotional abuse data to the most recent 12 months as the perpetrators are most likely the same. None of the people in the sample of interest experienced emotional abuse in the last 12 months by multiple partners; hence no further selection was required to link the data to the emotional abuse module.[5]

OUTCOME VARIABLE

The outcome variable of interest is a binary variable indicating the experience of repeat IPV within the last 12 months involving physical or sexual assault relative to not experiencing repeat violence involving assault. Note that observations for which this variable is recorded as a zero would include those experiencing repeat violence but not physical or sexual assault and those who did not experience repeat violence. This variable was constructed by counting those who had experienced violence by the index partner more than once in the last 12 months (using the data item 'Whether experienced violence by partner once or more than once in the last 12 months') and whether their most recent incident of physical or sexual assault by a partner occurred in the last 12 months using the data items ('When most recent incident occurred by Current Partner' and 'When most recent incident occurred by Previous Partner (lived with)').[6]

INPUT VARIABLES

The PSS contains a considerable number of variables encompassing personal, household and violence characteristics.[7] Note that the person-level, family-level, education, employment, income and financial insecurity variables relate to the respondent at the point of data collection. The following variables were coded and considered for inclusion in the analyses:

Person-level variables:

1. **Age** (24 or younger; 25-34; 35-44; 45 and above);
2. **Sex** (male or female);
3. **Place of birth** (whether respondent was born in Australia (yes or no));
4. **Remoteness of area of residence** (coded as major cities, inner regional, outer regional, remote and very remote);
5. **Socioeconomic disadvantage of area of residence** (deciles as defined by the National Index of Relative Socio-economic Disadvantage 2011 at the SA1 level (ABS, 2011));
6. **Disability status**:
   a) Whether respondent had any disability (yes or no);[8]
   b) Whether the respondent had an employment restriction due to disability (yes or no);
7. **Type of violent partner**: whether the most recently violent partner was a current or previous partner.

Family variables:

8. **Marital status:**
   a) Registered marital status (never married, married, widowed, divorced or separated);
   b) Social marital status (registered marriage, defacto marriage, not married);
   c) Whether divorced or separated (yes or no).
9. **Family structure:**
   a) Family composition (coded into couple without children, couple family, single-parent family, other);
   b) Number of children in household (0, 1, 2, 3+);
   c) Couple-parent family (yes or no, where no includes single-parent households, couple households with no dependent children, single-adult households and other types of households);
   d) Single-parent household (yes or no, where no includes couple-parent households with dependent children, couple households with no dependent children, single-adult households and other types of households).

Education, employment and income

10. **Education:**[9]
    a) Whether respondent's highest educational qualification is Year 10 or below (yes or no);
    b) Whether respondent has completed Year 12 (yes or no);
    c) Whether respondent has a bachelor's degree or higher (yes or no).
11. **Employment status:** employed (yes or no, i.e. both unemployed and not in labour force considered as 'no');
12. **Income sources:**
    a) Personal gross weekly income (coded into deciles);
    b) Whether received government pension, benefits or allowance as their sole source of income (yes or no).

Financial insecurity

13. **Inability to raise $2000 in an emergency:** Could not raise $2000 within a week in event of emergency (yes or no);
14. **Indicators of financial insecurity:**
    a) At least one indicator of financial insecurity

(yes if respondent answered 'yes' to any of the following categories: could not pay electricity, gas or telephone bills at the time; could not pay mortgage or rent payments on time; could not pay for car registration or insurance on time; could not make minimum payment on credit card; pawned or sold something because they needed cash; went without meals; were unable to heat or cool their home; sought financial assistance from friends or family; sought assistance from welfare or community organisation);

b) Two or more indicators of financial insecurity (yes if respondent answered 'yes' to two or more of the following categories: could not pay electricity, gas or telephone bills at the time; could not pay mortgage or rent payments on time; could not pay for car registration or insurance on time; could not make minimum payment on credit card; pawned or sold something because they needed cash; went without meals; were unable to heat or cool their home; sought financial assistance from friends or family; sought assistance from welfare or community organisation).

Experience of violence and abuse

15. **Experience of abuse before the age of 15:** (yes or no for the following categories: physical abuse before age 15, sexual abuse before age 15, physical or sexual abuse before age 15, witnessed violence towards a parent by a partner before age 15);

16. **Experience of current and/or previous partner emotional abuse:**
    a) Since the age of 15 (yes or no);
    b) In the last 12 months (yes or no).

Social support

17. **Sources of social support outside household in time of crisis:** (yes or no for each of the following categories: friend, neighbour, family member, work colleague, community, charity or religious organisation, local council or other government services, health, legal or financial professional).

Partner emotional abuse

18. **Types of partner emotional abuse experienced in the last 12 months** (each category as a separate variable coded as yes or no):
    a) Controlled or tried to control them from contacting family, friends or community;
    b) Controlled or tried to control them from using the telephone, internet or family car;
    c) Controlled or tried to control where they went or who they saw;
    d) Kept track of where they were and who they were with;
    e) Controlled or tried to control them from knowing about, having access to or making decisions about household money;
    f) Controlled or tried to control them from working or earning money;
    g) Controlled or tried to control their income or assets;
    h) Controlled or tried to control them from studying;
    i) Deprived them of basic needs such as food, shelter, sleep or assistive aids;
    j) Damaged, destroyed or stole any of their property;
    k) Constantly insulted them to make them feel ashamed, belittled or humiliated;
    l) Shouted, yelled or verbally abused them to intimidate them;
    m) Lied to their child/ren with the intent of turning them against them;
    n) Lied to other family members or friends with the intent of turning them against them;
    o) Threatened to take their child/ren away from them;
    p) Threatened to harm their child/ren;
    q) Threatened to harm their other family members or friends;
    r) Threatened to harm any of their pets;
    s) Harmed any of their pets;
    t) Threatened or tried to commit suicide.

Variables were excluded from the analyses based on the extent to which these may co-occur rather than precede IPV and repeat IPV incidents. These were those relating to whether a person's violent partner had been reported to police, whether they had experienced physical threat, sexual violence or sexual assault by any perpetrator more than once, whether they had experienced sexual violence by any perpetrator in the last 12 months. This is because with these variables it is unclear whether these relate to separate incidents or the IPV incidents of interest. The sequencing of many of these variables in relation to the IPV incidents of interest was unclear, for example it was unclear whether the incident reported to the police was the first or a subsequent incident, or whether the sexual violence experienced in the last 12 months was separate to any IPV sexual violence experienced. Hence, using these as correlates of repeat victimisation may be misleading.

Many of the perpetrator characteristics included in other IPV risk assessment tools, such mental health and substance abuse problems, were not available in the PSS. The PSS included some data items related to the current partner such as their employment status and income. However, comparable variables were not available for those who were victimised by a previous partner, therefore were not included in the analyses.[10]

It is worth summarising the features and drawbacks of the dataset in relation to the research question at this stage. First, the survey includes population and jackknife replicate weights. These enable us to obtain population-weighted estimates with bootstrapped standard errors, mitigating some of the problems associated with a small sample size. Furthermore, it provides us with confidence in the external validity of the estimates. Without weighting, it would be impossible to attribute the results to survey design or the presence of a true relationship between the factors. The dataset also includes extensive information on victim characteristics. This enables the examination of the utility of victim-related factors in predicting re-victimisation. The dataset does, however, suffer from some significant disadvantages for addressing the research question. First, the victim characteristics collected refer to the time of data collection. They may not reflect the victim's situation at the time of any violence experienced.[12] Second, the small sample size prevents us from examining partner characteristics. This is also because the PSS only collects information about the characteristics of the current partner. Third, we are unable to establish the sequence of violence, only which events occurred at any point in the last 12 months (e.g. more than one incident of violence and whether a person experienced partner emotional abuse).

STATISTICAL ANALYSIS

To identify factors affecting IPV re-victimisation, we first compared the distributions of each explanatory variable between those who experienced more than one violent incident by a partner within 12 months and those who experienced only one incident, and tested whether any differences between the groups were statistically significant at the .05 level.

We then estimated weighted logistic regression models predicting the outcome of interest (i.e. repeat IPV involving assault versus one-off experience of IPV or repeat victimisation not involving assault in the 12 months prior to data collection) based on the observed characteristics. The selection of variables into the model was conducted as follows: first, those variables which showed significant bivariate association with the relevant outcome were included. The variables which were non-significant at the .05 level in the regression model were subsequently dropped one at a time, starting with the variable with the highest *p*-value. Forward selection of the remaining variables was then conducted to include any other statistically significant explanatory variables in the final model, with highly collinear variables entered alternately and only the most significant retained, if any were significant. At each point the weighted models were tested for goodness-of-fit using an *F*-adjusted mean residual test calculated using the *estat gof* command in Stata (Archer & Lemeshow, 2006), where a rejection of the null hypothesis indicates poor fit.

The predictive validity of the models was evaluated using the estimates obtained from the best weighted model. Specifically, we obtained predicted probabilities of a person's likelihood of being re-victimised and applied a cut-off value based on which observations are classified. The observations with predicted probabilities above the cut-off were classified as a positive (re-victimised with an assault within 12 months), otherwise as a negative (not re-victimised with an assault within 12 months), resulting in the following measures of predictive accuracy:

- **Sensitivity**: The proportion of those who were classified as re-victimised by the model among those who were re-victimised
- **Specificity**: The proportion of those who were not classified as re-victimised by the model among those who were not re-victimised
- **Positive predictive value**: The proportion of those who were classified as being re-victimised who were observed to have been re-victimised
- **Negative predictive value**: The proportion of those who were classified as not being re-victimised who were not observed to have been re-victimised

A composite measure that can be obtained from the sensitivity and specificity of a model is the area under the receiver operating characteristic curve (AUC)**.** This measure plots the probability of detecting true signal (sensitivity) and the probability of detecting false signal (1-specificity) over various cut-off thresholds. The area under this curve encapsulates the ability of the model to detect differences between these groups. The AUC is judged to be:

- Acceptable if its value is between 0.7 and 0.8;
- Excellent if its value is between 0.8 and 0.9; and
- Outstanding if its value is above 0.9 (Hosmer & Lemeshow, 2004).

A worthwhile consideration in assessing the predictive validity of any model is whether it performs well outside the estimation sample. Hence we also undertake *k*-fold validation of the final weighted model, which splits the sample into *k* random, equal-sized groups (folds) before estimating the model *k* times, each time leaving one fold out. The predictive performance of the model is evaluated each time on the excluded fold. For this paper we set *k* between 10 to 20 folds, and for each *k* calculate the performance statistics by averaging across those obtained from each excluded fold.

RESULTS

DESCRIPTIVE STATISTICS

Table 2 presents the bivariate associations (both unweighted and weighted) between each of the explanatory variables and the outcome of interest (i.e. a re-victimisation episode within 12 months involving assault). The vast majority (roughly four in five) of IPV victims in the survey were women and were born in Australia. More than half reported that they had a disability and around one in five reported a disability that restricted them from employment. There were no statistically significant differences between repeat and other IPV victims in whether the violent partner was a current or previous partner, the victim's age, sex, disability status, or place of birth. The only two person-related variables that were significantly different across the groups were the person's socioeconomic status and remoteness of their residence. A larger proportion of those who lived in more disadvantaged and remote areas were re-victimised with an assault within 12 months. While significant group differences in proportions of single parents and people who were part of a couple with children were evident in the unweighted analysis, these were not significant once population weights were factored in.

There were significant differences between those who were re-victimised and those who were not on a number of variables related to education and employment. We observe that respondents with low levels of education and those whose sole source of income was a government pension, benefits or allowance were over-represented among those who were re-victimised, and respondents with Year 12, a bachelor's degree

Table 2. Weighted and unweighted bivariate associations between explanatory factors and IPV re-victimisation involving assault within 12 months

	Unweighted			Weighted		
Variable	Not re-victimised (n=191) (n(%))	Re-victimised (n=145) (n(%))	χ^2 *p*-value	Not re-victimised (%)	Re-victimised (%)	χ^2 *p*-value
Personal						
Age of person			.792			.536
30 and under	48 (25.1)	38 (26.2)		26.9	28.7	
31-40	63 (33.0)	44 (30.3)		28.6	27.3	
41-50	36 (18.8)	33 (22.8)		16.8	24.4	
51 and above	44 (23.0)	30 (20.7)		27.7	19.6	
Sex			.416			.329
Male	34 (17.8)	21 (14.5)		36.1	27.7	
Female	157 (82.2)	124 (85.5)		63.9	72.3	
Has any disability (yes)	114 (59.7)	76 (52.4)	.183	56.1	55.3	.915
Employment restriction (yes)	36 (18.8)	33 (22.8)	.379	18.3	20.9	.654
Born in Australia (yes)	141 (73.8)	118 (81.4)	.103	75.6	77.5	.779
Socioeconomic disadvantage quintile of postcode of residence			.002			.003
Quintile 1- most disadvantaged	24 (12.6)	42 (29.0)		6.9	30.5	
Quintile 2	33 (17.3)	29 (20.0)		18.7	24.9	
Quintile 3	50 (26.2)	24 (16.6)		24.5	14.1	
Quintile 4	46 (24.1)	28 (19.3)		24.3	18.7	
Quintile 5 – least disadvantaged	38 (19.9)	22 (15.2)		25.7	11.8	
Remoteness area (ARIA) - ASGS 2011			<.001			.008
Major cities	132 (69.1)	69 (47.6)		86.1	60.2	
Inner regional	24 (12.6)	28 (19.3)		8.5	24.5	
Outer regional, remote and very remote	35 (18.3)	48 (33.1)		5.3	15.3	
Type of violent partner			.057			.366
Current partner	103 (53.9)	63 (43.4)		59.6	65.4	
Previous partner	88 (46.1)	82 (56.6)		40.4	34.6	

Table 2. Weighted and unweighted bivariate associations between explanatory factors and IPV re-victimisation involving assault within 12 months - continued

Variable	Unweighted			Weighted		
	Not re-victimised (n=191) (n(%))	Re-victimised (n=145) (n(%))	χ^2 *p*-value	Not re-victimised (%)	Re-victimised (%)	χ^2 *p*-value
Family						
Registered marital status			.169			.461
Never married	64 (33.5)	54 (37.2)		35.4	40.9	
Divorced, separated or widowed	45 (23.6)	43 (29.7)		16.0	19.5	
Married	82 (42.9)	48 (33.1)		48.6	39.6	
Number of children aged 0-17 years in household			.389			.771
None	99 (51.8)	78 (53.8)		53.8	50.9	
1	29 (15.2)	18 (12.4)		15.4	16.5	
2	45 (23.6)	28 (19.3)		25.3	22.5	
3 or more	18 (9.4)	21 (14.5)		5.5	10.2	
One-parent household with dependent children (yes)	36 (18.8)	48 (33.1)	.003	12.1	17.0	.286
Two-parent household with dependent children (yes)	113 (59.2)	64 (44.1)	.006	65.2	65.8	.932
Education and employment						
Highest qualification is Year 10 or below (yes)	43 (22.5)	62 (42.8)	<.001	20.9	39.4	.020
Year 12 qualifications (yes)	124 (64.9)	64 (44.1)	<.001	70.5	51.5	.022
Bachelor's degree or higher (yes)	63 (33.0)	30 (20.7)	.013	43.4	18.4	.002
Employed (yes)	138 (72.3)	83 (57.2)	.004	72.1	61.0	.117
Receives government pension, benefits or allowance as sole source of income (yes)	33 (17.3)	47 (32.4)	.001	15.2	30.1	.007
In lowest income quintile (yes)	33 (17.3)	16 (11.0)	.108	16.0	17.3	.813
Financial insecurity						
Could not raise $2000 within a week in event of emergency (yes)	51 (26.7)	45 (31.0)	.384	23.0	34.4	.135
Could not pay bills or rent on time (yes)	66 (34.6)	66 (45.5)	.042	29.9	39.2	.250
At least one indicator of financial insecurity (yes)	74 (38.7)	76 (52.4)	.013	33.6	46.0	.135
Two or more indicators of financial insecurity (yes)	56 (29.3)	57 (39.3)	.055	26.8	30.7	.557
Experience of abuse						
Experience of abuse before age 15						
Sexual abuse before age 15 (yes)	36 (18.8)	43 (29.7)	.021	16.9	22.8	.318
Physical abuse before age 15 (yes)	41 (21.5)	31 (21.4)	.985	19.0	16.7	.674
Physical or sexual abuse (yes)	61 (31.9)	53 (36.6)	.376	28.7	29.2	.931
Witnessed violence towards a parent by a partner (yes)	53 (27.7)	46 (31.7)	.429	24.3	36.7	.135
Experience of violence since age 15						
Physical threats since age 15 (yes)	76 (39.8)	69 (47.6)	.153	39.1	42.9	.645
Sexual assault since age 15 (yes)	88 (46.1)	70 (48.3)	.689	44.6	38.6	.505
Sexual violence since age 15 (yes)	93 (48.7)	76 (52.4)	.499	46.6	42.6	.681
Experienced stalking since age 15 (yes)	60 (31.4)	57 (39.3)	.132	21.6	30.3	.204

Table 2. Weighted and unweighted bivariate associations between explanatory factors and IPV re-victimisation involving assault within 12 months - continued

Variable	Unweighted			Weighted		
	Not re-victimised (n=191) (n(%))	Re-victimised (n=145) (n(%))	χ^2 *p*-value	Not re-victimised (%)	Re-victimised (%)	χ^2 *p*-value
Social support						
Social support outside household in time of crisis						
Friend (yes)	150 (78.5)	97 (66.9)	.017	82.7	69.4	.073
Neighbour (yes)	38 (19.9)	25 (17.2)	.537	20.6	13.7	.249
Family member (yes)	155 (81.2)	107 (73.8)	.107	83.1	74.8	.190
Work colleague (yes)	61 (31.9)	41 (28.3)	.470	33.3	29.4	.609
Community, charity or religious organisation (yes)	41 (21.5)	34 (23.4)	.666	17.7	31.9	.125
Local council or other government service (yes)	35 (18.3)	13 (9.0)	.015	19.2	12.1	.213
Health, legal or financial professional (yes)	54 (28.3)	27 (18.6)	.041	26.5	12.3	.020
Emotional abuse						
Emotional abuse in last 12 months (yes)	85 (44.5)	111 (76.6)	<.001	39.0	75.9	<.001
Emotional abuse since age 15 (yes)	128 (67.0)	126 (86.9)	<.001	60.6	84.3	.005
How often emotional abuse experienced			<.001			<.001
All/most of the time	22 (11.5)	42 (29.0)		10.5	24.6	
Some of the time	18 (9.4)	44 (30.3)		9.5	22.7	
A little of the time/once only	45 (23.6)	25 (17.2)		19.0	28.6	
Did not experience emotional abuse in last 12 months	106 (55.5)	34 (23.4)		61.0	24.1	
Experience of specific emotional abuse behaviours						
Controlled or tried to control them from contacting family, friends or community (yes)	27 (14.1)	71 (49.0)	<.001	13.2	50.7	<.001
Controlled or tried to control them from using the telephone, internet or family (yes)	22 (11.5)	48 (33.1)	<.001	10.9	28.6	.005
Controlled or tried to control where they went or who they saw (yes)	28 (14.7)	59 (40.7)	<.001	14.6	35.8	.001
Kept track of where they were and who they were with (yes)	18 (9.4)	42 (29.0)	<.001	6.7	28.8	.002
Controlled or tried to control them from knowing about, having access to or making decisions about household money (yes)	25 (13.1)	44 (30.3)	<.001	17.9	23.8	.445
Controlled or tried to control them from working or earning money (yes)	15 (7.9)	30 (20.7)	<.001	5.4	13.9	.035
Controlled or tried to control their income or assets (yes)	16 (8.4)	40 (27.6)	<.001	7.8	23.9	.005
Damaged, destroyed or stole any of their property (yes)	24 (12.6)	52 (35.9)	<.001	10.2	38.6	<.001
Constantly insulted them to make them feel ashamed, belittled or humiliated (yes)	51 (26.7)	75 (51.7)	<.001	22.2	52.9	<.001
Shouted, yelled or verbally abused them to intimidate them (yes)	60 (31.4)	93 (64.1)	<.001	29.5	66.0	<.001
Lied to their child/ren with the intent of turning them against them (yes)	19 (9.9)	33 (22.8)	.001	8.5	12.7	.343
Threatened or tried to commit suicide (yes)	17 (8.9)	50 (34.5)	<.001	9.9	33.2	.007
Experienced anxiety or fear due to emotional abuse in the last 12 months (yes)	62 (32.5)	93 (64.1)	<.001	30.8	64.0	<.001
Whether experienced emotional abuse by more than one previous partner (yes)	10 (5.2)	26 (17.9)	<.001	2.8	9.8	.021

or higher were over-represented among those who did not experience re-victimisation. There was no difference between those who were re-victimised and those who were not with regard to employment or level of personal income. We observed no significant differences between repeat and non-repeat IPV victims in terms of financial insecurity when examining the population-weighted estimates but significant differences were evident in the proportions who could not pay their bills or rent on time and those who had at least one indicator of financial difficulty (both over-represented among those who were re-victimised) in the unweighted analyses. The largest difference between the groups was experience of partner emotional abuse since age 15. Those who had experienced partner emotional abuse were more likely to be re-victimised. Experience of child sexual abuse was also more common amongst repeat IPV victims than other IPV victims, but this difference was only significant for the unweighted sample. Approximately half of the respondents in both groups reported having experienced sexual assault or violence (by any perpetrator) since age 15. The only other statistically significant difference between the groups was for social support. A lower proportion of repeat IPV victims reported having received support from a health, legal or financial professional than those who were not re-victimised. The differences between the weighted and unweighted estimates on potentially meaningful variables such as financial insecurity, employment, and single parenthood suggest that population-weighted estimates should be used to avoid drawing inferences based on sampling error.

STATISTICAL MODEL

The results of the best weighted logistic regression model are presented in Table 3. Only five variables were found to be independently associated with repeat IPV assault victimisation relative to non-assault repeat victimisation or no repeat victimisation; socioeconomic quintile of residence, remoteness of residence, disability, highest level of education and emotional abuse in previous 12 months. Of these, the factor most strongly associated with repeat IPV assault was socioeconomic disadvantage of area of residence. The odds of a person being re-victimised with an IPV assault was ten times higher for someone living in an area ranking within the most disadvantaged quintile of the SEIFA index relative to a person residing in an area in the least disadvantaged socioeconomic quintile. Remoteness of the area of residence was also significant in the model, with those residing in an inner regional area being more likely to be re-victimised than those living in major cities. The difference in the odds of re-victimisation between IPV victims living in a remote area and those living in a major city was not significant.

IPV victims with any disability also had significantly higher odds of another IPV assault within 12 months, as did IPV victims who had not continued past Year 10 at school. Emotional abuse by a partner in the last 12 months in the form of controlling or attempts to control contacts with family, friends or the community was also strongly associated with repeat IPV assault within 12 months. The odds of being re-victimised were seven times higher if emotional abuse of this kind had recently been experienced by a victim. The interactions between different factors in the model and the predicted probabilities of re-victimisation are presented in the Appendix (Figure A1).

Model performance

Model fit was evaluated using the mean residual *F*-test. The *p*-value associated with the mean residual test *F*-statistic is non-significant, indicating that the model has reasonably good fit. The measures of within-sample predictive validity, obtained by applying a cut-off of 0.5 to the predicted probabilities from the model also indicate relatively good fit. The sensitivity measure indicates that 69 per cent of those who were re-victimised were classified as such by the model, and similarly, the specificity measure indicates that 70 per cent of those who were not re-victimised were classified as such by the model. The model's positive predictive value of .63 indicates that roughly 63 per cent of those who were predicted to be re-victimised were re-victimised, i.e. the positive classifications were correct three out of four times. The negative predictive value was .75 indicating that 75 per cent of all the observations the model classified as not being re-victimised did not report experiencing multiple IPV incidents involving assault in the 12 months preceding data collection. Overall, 69 per cent of cases were correctly classified by the model.

The subsequent rows report the cross-validated classification statistics. These are the averages of measures of predictive validity of the model when using *k*-fold validations for each *k* between10 and 20. The average AUCs across each *k* are remarkably similar to that reported in Table 3 with a similar range in the confidence interval. The AUCs estimated on the excluded folds decline slightly but remain acceptable (higher than .70). Model specificity is largely maintained, while specificity erodes slightly, especially as *k* increases. PPV and NPV were stable across the choice of *k*. The proportions of correct predictions were also robust to the selection of different values of *k*. These results collectively indicate that the model's out-of-sample performance is consistent with its in-sample performance and we do not observe substantial reductions in the model's discriminatory power based on particular subsets of the data.

Table 3. Logistic regression model predicting domestic violence re-victimisation within 12 months involving an assault

Variable	Odds Ratio	Std. Err.	*p*-value
Socioeconomic quintile of postcode of residence (relative to quintile 5 – least disadvantaged)			
Quintile 4	1.47	0.87	.522
Quintile 3	1.29	0.84	.700
Quintile 2	3.03	1.89	.080
Quintile 1 - most disadvantaged	10.48	9.10	.009
Remoteness of postcode of residence (relative to major cities)			
Inner regional	4.73	3.00	.017
Outer regional, remote and very remote	3.07	2.08	.103
Respondent has a disability	2.57	1.00	.018
Highest educational attainment is Year 10 or below	2.58	1.12	.032
Emotional abuse experienced in the last 12 months (any partner) Partner controlled or tried to control them from contacting family, friends or community	7.59	2.59	<.001

Table 4. Goodness-of-fit and classification statistics for original model and cross-validations

Whole sample	
AUC (95% C.I.)	.760 (.707, .812)
Sensitivity	0.691
Specificity	0.697
PPV	0.630
NPV	0.750
Correctly predicted	69.3%

k	Estimation sample	Validation group					
	AUC (95% C.I.)	AUC (95% C.I.)	Sensitivity	Specificity	PPV	NPV	Correct
10	.761 (.706, .816)	.726 (.539, .910)	.664	.666	.629	.728	66.1%
11	.761 (.707, .816)	.749 (.567, .931)	.710	.653	.630	.740	66.7%
12	.760 (.706, .815)	.732 (.524, .937)	.673	.662	.624	.734	66.4%
13	.761 (.707, .815)	.717 (.498, .931)	.670	.672	.603	.710	67.0%
14	.761 (.707, .815)	.737 (.523, .941)	.700	.672	.619	.733	67.3%
15	.760 (.706, .814)	.730 (.496, .951)	.690	.646	.615	.730	64.9%
16	.761 (.707, .814)	.727 (.450, .956)	.703	.638	.613	.731	64.9%
17	.760 (.706, .813)	.722 (.446, .951)	.696	.621	.634	.716	64.3%
18	.760 (.706, .814)	.733 (.486, .958)	.733	.636	.625	.726	66.9%
19	.760 (.707, .814)	.728 (.433, .968)	.718	.628	.630	.720	65.2%
20	.761 (.707, .814)	.728 (.430, .972)	.731	.615	.637	.727	65.8%

DISCUSSION

The aim of this study was to use microdata from the ABS Personal Safety Survey 2016 to identify factors that distinguish IPV victims who are re-victimised with an episode of assault from those who experience only one violent episode. A wide range of covariates encompassing personal sociodemographic, family, employment, education, financial security and emotional abuse variables were considered for inclusion in the model. The best weighted logistic regression model indicated that only five factors were significantly associated with the risk of being re-victimised with an assault within 12 months: living in an area within the most disadvantaged socioeconomic quintile, experiencing emotional abuse in the form of a partner controlling or attempting to control contact with family, friends or the community, living in an inner regional area, low educational attainment and having a disability. The performance of this model was at a level considered to be acceptable (AUC=.760) and did not significantly diminish under cross-validation.

Most existing IPV risk assessment tools contain a large number of questions about the characteristics of the perpetrator, their criminal history or prior abusive behaviours, as well as other potentially relevant situational and victim-specific factors. However, the current study suggests that a risk assessment tool based on limited and readily accessible information can discriminate between repeat and non-repeat IPV victims at the same level as, or in some cases better than well-established, more comprehensive, risk assessment tools. This study obtained a relatively high level of explanatory power using only five variables out of a large list. This complements the findings of other research which suggest that tools with a small number of variables can be highly predictive of repeat IPV (Berk, He, & Sorenson, 2006; Mason & Julian, 2009).

Having said this, these results do not discount the possibility that there may be other important factors to consider in developing IPV risk assessment tools, because the current study was limited to factors available in the PSS data. Indeed, Ringland (2018) identified a number of perpetrator characteristics that were significant independent predictors of repeat victimisation, including unemployment, substance abuse, mental health issues and criminal history. It is possible that the inclusion of additional information related to the perpetrator and/or the context in which the violence occurred could further boost predictive power of the model. Information on any recent separations from a partner may also be critical in predicting re-victimisation as it is a risk factor for intimate partner homicide (Wilson & Daly, 1993). We may also expect that police involvement or other criminal justice responses to the violent incident may affect the risk of further victimisation and therefore should be considered in any risk estimations. But again, the PSS data does not adequately capture this information.

There are several other study limitations that should be acknowledged here. First, unlike Ringland (2018), this analysis relied on cross-sectional survey data to measure further victimisation rather than data collected through repeated measures. It is unclear from our cross-sectional data whether the explanatory variables included in the model 'predicting' risk of repeat victimisation preceded, succeeded or co-occurred with the reported IPV incident. Any significant relationship found between our explanatory factors and the outcome can therefore only be interpreted as associative, not as causal. While data on whether a person reported their violent partner to the police were available in the dataset, we could not ascertain whether this report pertained to the first incident in the last 12 months, subsequent incidents, or previous violence. A further concern is the relatively low sample size used to estimate the models. This study was based on 336 observations, 145 of whom experienced IPV re-victimisation within 12 months and 191 of whom did not. While population weights were used to attempt to account for any disparities in sampling probabilities, it is likely that more precise, and potentially different, estimates might be obtained from a larger sample. Finally, the generalisability of these findings to the broader IPV victim population is not known. The partner violence module of the data used in this study (which recorded re-victimisation) only included incidents related to partners who were co-habiting or formerly co-habiting with the victim. These data also did not capture separately for each incident whether a police report was made. Thus, it is possible that the factors identified here as significant may not discriminate as strongly for incidents of repeat IPV that occur between non-cohabiting partners or for those that result in a subsequent police report. Furthermore, there are likely to be differences in the types of incidents which are reported in a survey setting, compared to those reported to the police.

Risk assessment tools are necessary to ensure that scarce resources are optimally allocated. However to date there is little empirical evidence to support their widespread use in assessing risk of repeat IPV victimisation. The model described here achieved better discrimination than several established tools for predicting IPV. However, to translate these findings into a risk assessment tool to be used in the NSW context would require further empirical research validating the predictive accuracy of these factors (and other available data) in a NSW sample. This process should be designed to include: 1) a well-defined outcome variable which defines the type of abusive behaviour and the timeframe for repeat victimisation; 2) longitudinal data collection to ensure that the risk factors are those which precede future incidents of IPV assault; and 3) the collection of a wider range of potential predictor variables, including (a) those that capture differences in risk of repeat victimisation for victims who return to their abusive partner as opposed to those who do not, and (b) those that capture police and other institutional responses to

previous incidents and (c) those that capture relevant offender characteristics. The factors which are most predictive of repeat IPV in that setting then should be identified through a similar procedure used in this study. The resulting model can then be operationalised as a risk assessment tool, and iteratively validated to ensure its integrity over time. As with all decision support tools, however, final decisions about risk should not be based solely on the output of the DV risk assessment tool as police and other responders to IPV will always be privy to risk-relevant information that cannot be captured in a risk assessment tool. Furthermore, the predictive ability of any IPV tool depends on how data collection is implemented and whether data items are interpreted and thus assessed in the same way. Discrepancies in the extent and method of application could erode the uniformity of standardised assessment and render the tool redundant. Thus iterative development of a tool should attempt to maximise both the fidelity of assessment and the predictive validity of the assessment items.

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NOTES

1. Prior to January 2017, a victim was also automatically classified at serious threat if they had 2 or more prior domestic violence related incidents recorded by police.
2. A description of how these weights were derived can be viewed in the Data Quality and Technical Notes section of the PSS User Guide (ABS, 2018b) under the subsection 'Derivation of replicate weights'.
3. This was done using the violence prevalence level variable allvpart (when the most recent incident occurred by Current or Previous Partner (lived with) per violence type).
4. This was imputed using the Violence Prevalence variables *allvcurr* and *allvprev* for 10 observations.
5. Consequently, we interpret the variables in this file as experience of emotional abuse within the last 12 months, rather than necessarily indicating emotional abuse perpetrated by the partner in question.
6. Note that this means we cannot discern whether the most recent incidence of IPV was an assault due to the timeframes recorded in the PSS. As the most recent timeframe involves the past 12 months, which is also the period over which repeat victimisation is examined, this outcome variable identifies people who experienced multiple incidents within the past 12 months, who also had an incident of physical or sexual assault perpetrated by a partner within the 12 months prior to data collection.
7. The full list of variables available in the microdata can be downloaded from the ABS (2018c).
8. A disability or restrictive long-term health condition exists if a limitation, restriction, impairment, disease or disorder has lasted, or is expected to last for six months or more, which restricts everyday activities. It may include one or more of the following categories: sight; hearing or speech; physical; intellectual; psychological; and head injury, stroke or brain damage.
9. These were also tested as a single variable and found not to add predictive value.
10. Similarly, while those victimised by a previous partner would have data on the recentness of the separation with the partner, this data would be unavailable for those who were victimised by a current partner by definition. While ideally both these and variables related to the current partner would be able to be incorporated, the small sample size of this study seems to preclude that.
11. A description of how these weights were derived can be viewed in the Data Quality and Technical Notes section of the PSS User Guide (ABS, 2018b) under the subsection 'Derivation of replicate weights'.
12. Personal characteristics such as the country of birth are fixed. A further advantage of restricting the timeframe of violence to the past 12 months prior to data collection is that the likelihood of mismatches between characteristics at the time of survey and characteristics at the time violence experienced are reduced.

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APPENDIX

HEAT MAP OF PREDICTED PROBABILITIES

One way of reporting the predicted probabilities of a logistic regression is using a heat map. This a visual representation of risk based on combinations of the observed factors. The heat map for the final weighted model reported in the text is presented in Figure A1 below. The predicted probabilities are denoted by colours; red representing a higher probability and green a lower probability of re-victimisation, with yellow representing the median of the predicted probabilities (approximately .05). As reported in the model, those who experienced partner emotional abuse, are more socio-economically disadvantaged, reside outside of major cities and have low levels of education are at greater risk of repeat re-victimisation.

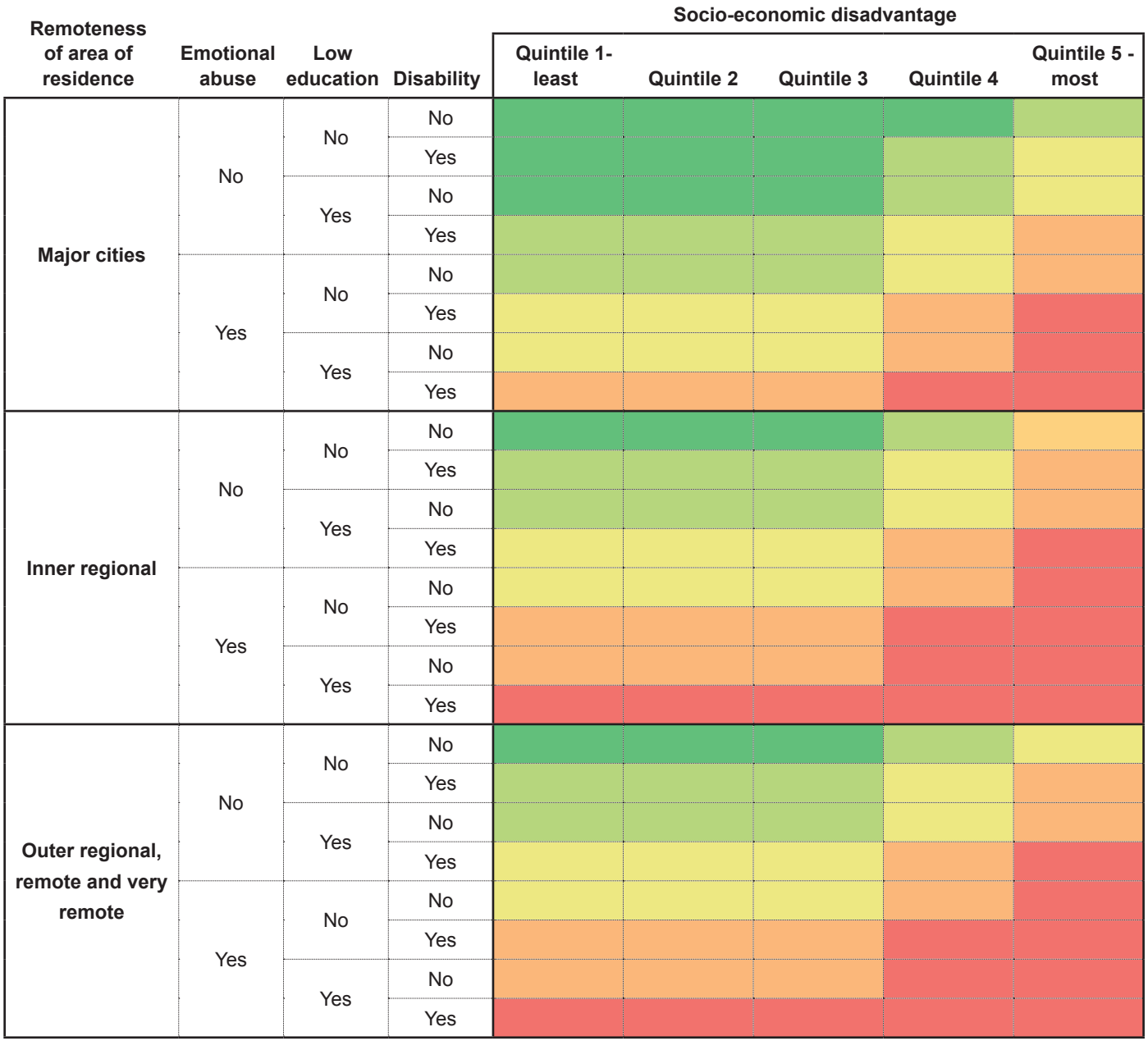
CLASSIFICATION TREE ANALYSIS

We implemented classification and regression tree (CART) techniques on the unweighted data to identify whether the significant factors obtained in the weighted logistic regression models could achieve a comparable level of predictive accuracy as the weighted logistic regression models reported in the body of this report. The advantage of a classification tree over a logistic regression model is the latter is much easier to interpret and apply. Instead of calculating predicted probabilities across a range of covariate patterns (i.e. unique combinations of covariates), classification trees mostly use binary splits to combine categories of variables to produce decision rules for classification (Hastie, Tibshirani, & Friedman, 2001). If the interactions of particular characteristics predict the outcome better than each characteristic on its own, CART will outperform logistic regression.

An example of a CART model in IPV is Berk, He, and Sorenson's (2005) classification tree model of domestic violence re-victimisation which produced three decision rules to predict whether the police would be called to a household for a future domestic violence incident: 1) if the police had previously been called more than three times to a household; 2) if the police had been called three or fewer times and the perpetrator was reported to destroy property when angry and the perpetrator was unemployed; and 3) if the police had been called three or fewer times, the perpetrator was reported to destroy property when angry, was employed, and was reported to have threatened to kill the victim or someone else in the family in the past.

The CART model was implemented using the *rpart* module in R. First, we estimated trees using the five variables from the best weighted logistic regression model (i.e. living in an area within the most disadvantaged socioeconomic quintile, experiencing emotional abuse in the form of a partner controlling or attempting to control contact with family, friends or the community, the

Figure A1. Heat map of predicted probabilities based on predictors included in main logistic regression model



remoteness of a person's area of residence, low educational attainment and disability status). Then we pruned the tree based on the number of branches yielding the lowest cross-validated error. This means that the model was restricted to the number of branches which produced the lowest average classification error when applied to various random subsets of the data. Hence, the tree for which this value is the lowest is that which is most robust to changes in observations in the training set. While the use of variables found to be significant in weighted logistic regression models in the tree model may alleviate some concern about the generalisability of these factors to the broader population, we should still be cautious as the classification tree method is highly sensitive to the dataset being used, especially when small numbers of observations are used in estimation. This is because each split divides the dataset into smaller groups of observations and thus further splits are defined based on fewer and fewer observations. Given that we apply this technique to a relatively small sample, we present the classification tree model only to diagnose whether particular combinations of variables can potentially predict domestic violence re-victimisation involving assault better than or at a level equivalent to logistic regression models.

Figure A2 presents the pruned classification tree obtained from the significant predictors from the weighted logistic regression model, which classifies observations into being re-victimised with an assault within 12 months or not based on splits in the input variables. The number of correctly classified observations and the number of observations falling within the node are presented for each terminal node (i.e. nodes where no further splits in the data are applied).

The final tree model first splits the data based on the victims' experience of emotional abuse in the last 12 months. The 238 observations who did not experience that type of abuse were classified as not being re-victimised. Among those who experienced emotional abuse in the last 12 months, the 38 observations who did not reside in a major city were classified as being re-victimised, the 15 observations who resided in a major city but in an area within the lowest socioeconomic quartile were classified as being re-victimised and the 16 observations who resided in a major city not in the lowest socioeconomic quartile but had low levels of educational attainment were also classified as being re-victimised. The remaining 29 observations involving people who experienced the relevant type of emotional abuse but resided in an area within a major city which was not within the lowest socioeconomic quintile and did not have low levels of educational attainment were classified as not being re-victimised.

In summary, the tree includes five terminal nodes. Classification statistics for each of these nodes and for the whole model are presented in Table A1.

There are several things to note about this model. The first is that the sensitivity is relatively low (.414). While three terminal nodes predicted re-victimisation, the number of observations who fell within these categories was relatively low. While many of those who did not experience emotional abuse were not re-victimised (the first terminal node), the model with the least error did not further divide these groups in order to identify those who were re-victimised within this group. This is likely related to the high level of specificity (.859) achieved by the model, as the emotional abuse measure was relatively good at discriminating between those who did not experience re-victimisation and those who did. While the model correctly classifies a slightly larger proportion of the respondents, the estimated AUC of .69 is lower than that of the logistic regression. It is unsurprising that this approach was slightly less effective, on balance, at identifying re-victimisation than the logistic regression as the loss function was not altered (e.g. to penalise false negatives more than false positives) and a small sample was used in the analysis. This technique might be more effective with more data. However, it does provide an indication of how some of these variables can be combined into decision rules to assess the risk of re-victimisation as in Berk, He, and Sorenson (2005).

Figure A2. Pruned classification tree based on significant predictors from best weighted logistic regression model

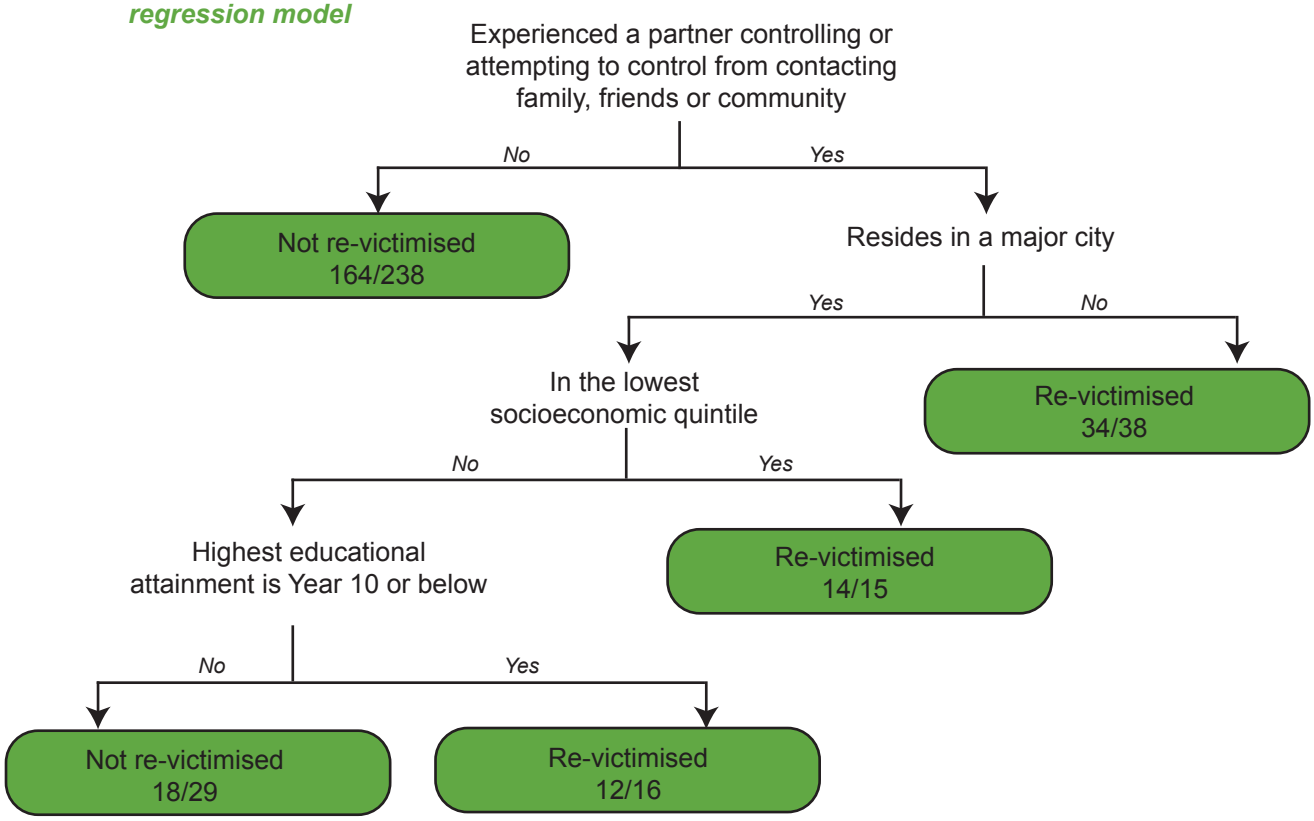


Table A1. Classification statistics for terminal nodes and overall classification tree model

	Classification			
Terminal node	**Re-victimised**	**Not re-victimised**	**Correct**	**%**
Did not experience a partner controlling or attempting to control them from contacting friends, family or the community	0	238	164	69%
Experienced a partner controlling or attempting to control them from contacting friends, family or the community AND did not reside in a major city	38	0	34	89%
Did not experience a partner controlling or attempting to control them from contacting friends, family or the community AND resided in a major city AND not in an area within the most disadvantaged quintile	15	0	14	93%
Did not experience a partner controlling or attempting to control them from contacting friends, family or the community AND resided in a major city AND not in an area within the most disadvantaged quintile AND highest educational attainment was Year 10 or below	16	0	12	75%
Did not experience a partner controlling or attempting to control them from contacting friends, family or the community AND resided in a major city AND not in an area within the most disadvantaged quintile AND highest educational attainment was not Year 10 or below	0	29	18	62%
Whole model	**69**	**267**	**242**	**72%**
Measure				**Value**
AUC				.695
Sensitivity				.414
Specificity				.859
Positive predictive value				.870
Negative predictive value				.614

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