



# Social determinants of depression among mid-to-older aged Australians: A prospective study of the effects of neighbourhood disadvantage and crime

Vincent Learnihan<sup>a,\*</sup>, Yohannes Kinfu<sup>b,c,d,e</sup>, Gavin Turrell<sup>a,f</sup>

<sup>a</sup> Health Research Institute, University of Canberra, Canberra, Australia

<sup>b</sup> Faculty of Health, University of Canberra, Canberra, Australia

<sup>c</sup> College of Medicine, Qatar University, Doha, Qatar

<sup>d</sup> Department of Health Metrics, University of Washington, Seattle, USA

<sup>e</sup> Murdoch Children's Research Institute, Melbourne, Australia

<sup>f</sup> Centre for Urban Research, RMIT University, Melbourne, Australia

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## ABSTRACT

**Background:** Few studies examining social determinants of depression have incorporated area level objectively measured crime combined with self-report measures of perceived crime. How these factors may interrelate with neighbourhood disadvantage is not well understood, particularly in Australia, where mental health disorders are of major concern. This study examined relationships between area-level objective crime, self-reported perceptions of crime, neighbourhood disadvantage and depression, and potential mechanisms by which these variables indirectly lead to depression.

**Methods:** This study used data from the HABITAT Project, a representative longitudinal study of persons aged 40–65 years residing in 200 neighbourhoods in Brisbane, Australia, during 2007–2016. A prospective sample of residentially stable persons who reported depression at two years (n = 3120) and five years (n = 2249) post-follow-up was developed. Area level objective crimes were categorised as either crimes against the person, social incivilities or unlawful entry. Logistic regression was used to establish relationships with depression, followed by a decomposition analysis to establish potential mechanisms.

**Results:** Neighbourhoods in the highest quartile of crimes against the person had an increased risk of individuals reporting depression at all periods of follow-up. Associations were also found between unlawful entry and depression. Decomposition analysis indicated a positive and significant total effect of crime against the person on depression for all periods of follow-up, while an indirect effect of perceived crime was found to partially explain this relationship at 2-years after baseline (prop. Mediated = 46.5%), and at either or both periods of follow-up (prop. Mediated = 53.7%), but not at 5-years follow-up.

**Discussion:** Neighbourhoods with the highest levels of crime against the person may influence depression over time through a pathway of perceived crime. Perceived crime, particularly in areas of high crime against the person should be considered as part of a multi-faceted strategy aimed at improving population mental health.

## 1. Introduction

Depression is among the top non-fatal health outcomes, especially in more developed nations, including Australia (World Health Organization, 2017). Recent international evidence from a meta-analysis estimated a lifetime prevalence of depression of 10.8% globally (Lim et al., 2018). Depression significantly burdens families and communities and has a life-course impact on individuals (Colman & Ataulhjan, 2010). While the underlying causes of depression are multi-faceted,

socio-ecological factors have long been recognised as potential contributors to the complex aetiology of depression (Rautio, Filatova, Lehtiniemi, & Miettunen, 2018).

Among such socio-ecological factors, police-reported crime has been identified as a key contextual predictor associated with depression (Baranyi, Di Marco, Russ, Dibben, & Pearce, 2021). Mental health impacts have been identified from direct exposure to crime (as a victim or witness) as well as indirectly, mainly operating at the neighbourhood level involving physical and social environments, perceived

\* Corresponding author. Health Research Institute, University of Canberra, University Drive, Bruce, ACT, 2617, Australia.

E-mail address: [vincent.learnihan@canberra.edu.au](mailto:vincent.learnihan@canberra.edu.au) (V. Learnihan).

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environment and fear of crime (Fowler, Tompsett, Braciszewski, Jacques-Tiura, & Baltés, 2009; Generaal et al., 2019; Lorenc et al., 2012).

From an indirect impact of crime perspective, theory suggests living in high crime areas may increase individual risk of depression through chronic stress, interfering with social relationships, and magnifying the impact of adverse life events (Cutrona, Wallace, & Wesner, 2006). Additionally, conceptual pathways have been proposed whereby individuals' level of resilience, sense of control and perception of their residential environment may affect vulnerability to depression for those living in such environments (Blair, Ross, Garipey, & Schmitz, 2014).

Prior studies of depression have identified an association with crime using both objective (police reported) and self-reported measures of crime and safety (Curry, Latkin & Davey-Rothwell, 2008; Lin, Kim, Liao, & Park, 2019; Secretti, Nunes, Schmidt, Stein, & Santos, 2019; Weisburd et al., 2018). A recent systematic review found that individual perceptions of crime were more strongly associated with depressive symptoms than aggregated perceptions of crime or area level objectively measured crime, however, rarely did studies of depression integrate both objective and perceived measures of crime into the same study (Baranyi et al., 2021). This is critical from an intervention standpoint as understanding what level of objectively measured crime may influence perceptions of crime may help to guide initiatives to reduce the indirect impact of objective crime on mental health.

One U.S. study of adults aged 50–74 years found areas of higher violent crime (police reports of rape, robbery, and aggravated assault), and those with greater concern for neighbourhood safety experienced elevated levels of depressive symptoms (Wilson-Genderson & Pruchno, 2013). This study and other health research have demonstrated a small yet significant positive association between objective and perceived crime (Shareck & Ellaway, 2011; Van Bakergem, Sommer, Heerman, Hipp, & Barkin, 2017). The weak association suggests residents within a particular neighbourhood may perceive crime differently and that factors such as measurement of perceptions (e.g. self-report scales may include constructs of perceived crime, personal safety or fear of crime), potential under-reporting of local crime events, and contextual factors such as the physical environment and media-reporting, all contribute to how crime is perceived beyond the local occurrence of crime itself (Foster, Wood, Christian, Knuiman, & Giles-Corti, 2013; Jahiu & Cinnamon, 2021). Particular groups, including those who are depressed, may also perceive their environment as worse than it is, with cross-sectional studies particularly vulnerable to such bias (Chum, O'Campo, et al., 2019; Rautio et al., 2018). One longitudinal study found higher psychological distress over time leads to higher fear of crime, rather than the opposite pathway (Foster, Hooper, Knuiman, & Giles-Corti, 2016). These factors highlight the need to investigate further the role of perceived and objective measures of local crime in depression and address potential bias by adopting more robust study designs.

Existing literature supports an association between neighbourhood disadvantage and depression, although findings based on extended follow-up periods tend to be inconsistent (Barnett, Zhang, Johnston, & Cerin, 2018; Richardson, Westley, Garipey, Austin, & Nandi, 2015). It has been argued that objective crime is one of the few plausible mechanisms operating at an area-level, which explains higher risk of mental health problems in disadvantaged communities (Baranyi, Cherrie, Curtis, Dibben, & Pearce, 2020; Joshi et al., 2017). Criminology literature has established that neighbourhood disadvantage is strongly associated with the spatial concentration of violent, drug and property crime (Lakeman, Benier & Wickes, 2021). Weaker social ties and diminished informal social control in disadvantaged neighbourhoods have been proposed as one explanation for this (Sampson, Raudenbush & Earls, 1997; Wickes & Hipp, 2018). Extending existing neighbourhood crime theory to outcomes of depression may yield an improved understanding of pathways involving neighbourhood disadvantage, objective and perceived crime and depression.

Studies investigating the role of crime as a potential determinant of depression have a number of limitations. Firstly, the majority of studies do not cover both objective and subjective measurements of crime at the same time. Secondly, the type and frequency of local crime occurring in neighbourhoods may vary in its effect on individuals, yet studies have rarely examined different types of crime in relation to depression. Thirdly, few studies have investigated the mechanisms or pathways by which crime may influence depression. Fourth, many studies poorly capture the temporal ordering of influence allowing for study bias. Fifth, the studies are mostly from the US where the local context and severity of crime can differ from that in Australia.

To address these limitations, three study aims were developed as follows: (1) To examine prospectively, the main effects of area level objectively measured crime, perceived crime and neighbourhood disadvantage on the likelihood of depression in the Australian context, (2) to examine whether relationships between objective crime and depression are mediated by perceived crime, and (3) to examine whether the relationship between neighbourhood disadvantage and depression is mediated by either objective or perceived crime. The following three hypotheses further guided our study. Firstly, relationships with depression will depend on the type of area level objective crime measure used, crime against the person, social incivilities or unlawful entry. Secondly, the relationship between measures of objective crime and depression will be mediated by perceived crime. Thirdly, the association between neighbourhood disadvantage and depression will be mediated by both measures of objective crime and by perceived crime.

## 2. Methods

### 2.1. Ethics

HABITAT received ethical clearance from the Queensland University of Technology Human Research Ethics Committee (Ref. Nos. 3967H & 1300000161).

### 2.2. Study design and sample

Details about the HABITAT study can be found elsewhere (Burton et al., 2009; Turrell et al., 2020). Briefly, a two-stage probability sampling design was used to select a stratified random sample of 200 neighbourhood Census Collection Districts (CCDs), and within each neighbourhood, a random sample of people aged 40–65 years (on average 85 people per CCD). The baseline HABITAT sample (2007) was broadly representative of the wider Brisbane population (Turrell et al., 2010). A structured self-administered questionnaire was sent to 17,000 potentially eligible participants in May 2007 using a mail survey method developed by Dillman and colleagues (Dillman, Smyth & Christian, 2014). After excluding 873 out-of-scope contacts (i.e. deceased, no longer at the address, unable to participate for health-related reasons), 11,035 useable surveys were returned, yielding a baseline response rate of 68.3%: the corresponding response rates from in-scope and contactable participants 2009, 2011, 2013 and 2016 were 72.6% (n = 7866), 67.6% (n = 6900), 67.5% (n = 6520) and 58.8% (n = 5187), respectively. This particular study adopts a prospective study design, tracking the cohort from 2009 onwards. Hereafter, the 2009 round will be referred to as T0, 2011 as T1, 2013 as T2 and 2016 as T3. Fig. 1 indicates how the sample was derived. The outcomes of interest were available from T1 onwards, which allowed for two periods of follow up (T2, T3). (Turrell, Hewitt, Rachele, Giles-Corti, & Brown, 2018).

### 2.3. Measures

#### 2.3.1. Neighbourhood disadvantage

Derived from the ABS' Index of Relative Socioeconomic Disadvantage (IRSD), this measure reflects each area's overall level of

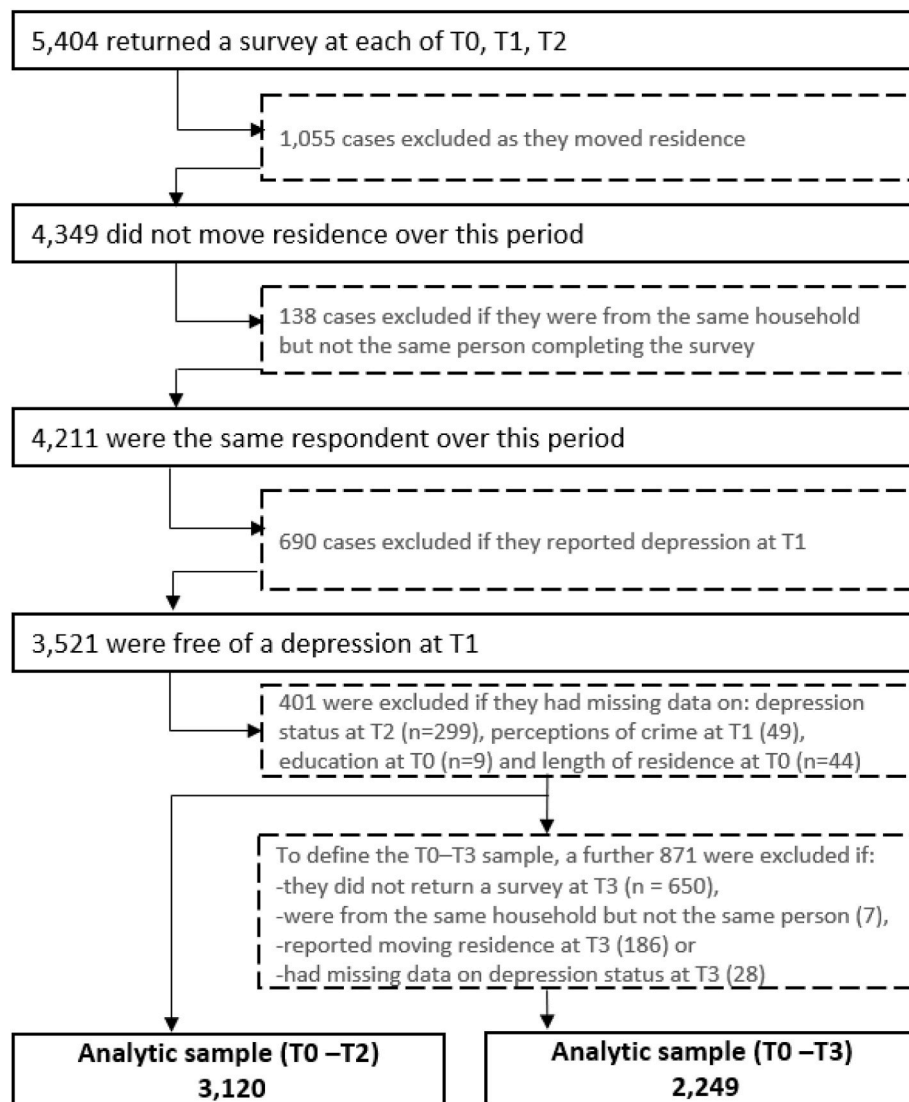


Fig. 1. Flow chart indicating how the two analytic samples were derived.

disadvantage based on 17 socioeconomic attributes, including education, occupation, income, and unemployment (Australian Bureau of Statistics, 2018). Neighbourhood disadvantage was measured at the scale of CCD. The median land area of a HABITAT neighbourhood CCD was 0.27 km<sup>2</sup> (Range: 0.02 km<sup>2</sup>–70.7 km<sup>2</sup>) with 50 percent of them having 542 persons or more (Range: 209–1661) at the time of sampling in 2007. For analysis, the 200 HABITAT neighbourhoods were grouped into quintiles based on their IRSD scores with Q1 denoting the 20% least disadvantaged areas (n=40) in Brisbane and Q5 the 20% most disadvantaged areas (n = 40). This exposure variable was measured at T0.

### 2.3.2. Objective crime

Number of police reported crimes was used as an objective indicator and measured using data geocoded to street address locations in Brisbane for 2009 sourced from the Queensland Police Service (QPS). Using Geographic Information Systems (GIS), the total number of crimes that occurred during 2009 were assigned to 1 km network buffers around each survey respondent's residence. Three QPS categories of crime were used: crimes against the person (homicide, assault, sexual offenses, robbery, and other offenses against the person), social incivilities (drug offenses, prostitution offenses, trespassing and vagrancy, and good order offenses) and unlawful entry (unlawful entry without violence-dwelling, unlawful entry with intent – shop, unlawful entry with intent – other).

For analysis, the crime variables were grouped into quintiles. Q1 representing the 20% of areas with the lowest crime counts and Q5 denoting the 20% of areas with the highest crime counts. We used this classification in all cases, except when the variable was used as a mediator. In the latter case, the continuous version of the variable was used (see below under 2.4 *Statistical Analysis*). This exposure variable was measured at T0.

### 2.3.3. Perceived crime

Participants were presented with six statements and asked to respond on a 5-point Likert-type scale, ranging from strongly disagree to strongly agree. The statements asked about the level of crime in the neighbourhood, including whether the level of crime makes it safe to walk in the neighbourhood during the day or night. The tools have acceptable validity and reliability and were adapted from the Neighbourhood Environment Walkability Scale (NEWS) questionnaire (Cerin, Conway, Saelens, Frank, & Sallis, 2009; Cerin, Saelens, Sallis, & Frank, 2006; Turrell et al., 2011). We applied Principal Component Analysis (PCA) to create a composite measure known as “perceived crime”. Specifically, we employed varimax rotation, which revealed that the six items loaded on one factor with a Cronbach's alpha of 0.80. The PCA factor was rescaled to range from 0 to 10, with higher scores indicating respondents who perceived their neighbourhoods as having a high level of crime and

being unsafe ( $M = 2.91$ , interquartile range [IQR] = 2.50–3.95). Based on prior evidence for creating more valid neighbourhood exposure measures (Chum, O'Campo, et al., 2019) the individual scores on perceived crime were then aggregated to the 1 km network buffers to create a neighbourhood exposure measure representing perceived crime. To ensure appropriate temporal ordering this variable is measured at T1, following exposure to objective crime which is measured at T0.

### 2.3.4. Depression

Depression was the primary outcome of interest and was measured using a self-reported response to the following survey question: *Have you ever been told by a doctor or nurse that you have depression?* HABITAT survey respondents were asked to tick 'yes' if the condition had lasted, or was likely to last, for six months or more. Self-reported measures of chronic diseases have generally been shown to be valid and have been used extensively in Australian health research (Australian Bureau of Statistics, 2009) (Martin, Leff, Calonge, Garrett, & Nelson, 2000).

Data on depression status were available at three time points: T1 (2011), T2 (2013) and T3 (2016). We used data on depression at T1 to select only those participants without the condition and followed the respondents over time to determine their status at the later time points of T2 and T3. While depression is recognised as an episodic condition (Colman & Ataullahjan, 2010), selecting only those respondents who did not report depression in T1 helped to minimise same-source (or directional) bias that could result in those with depression reporting worse neighbourhood conditions (Stafford, McMunn & De Vogli, 2011). In addition to the creation of depression outcome variables for T2 and T3, an outcome variable was also developed which identified respondents who reported depression at T2 and/or T3.

### 2.3.5. Covariates

Individual sociodemographic variables used in the analyses were based on past reviews of the literature (Baranyi et al., 2021; Barnett et al., 2018; Mair, Diez Roux & Galea, 2008) and included age, gender, length of residence, and measures of Socioeconomic Position (SEP) including household income, education, and occupational status. When controlling for these variables in mediation analyses, the variables were fixed at their median values. These variables were measured at T0.

## 2.4. Statistical Analysis

An analytic framework illustrating the direction of expected relationships is shown in Fig. 2. To minimise the risk of bias associated with health selection into neighbourhoods (i.e., those with depression relocating to more socioeconomically disadvantaged areas), survey respondents who reported moving residence at any time during the study were excluded. The prospective study design was characterised by a 2-

year follow up period (from T1 to T2) and a 5-year follow-up period (from T1 to T3). At 2-year follow up (T2), the analytic sample was 3120 survey respondents (median n per neighbourhood = 20, range: 1–57). At the 5-year follow up (T3), the analytic sample was 2249 survey respondents (median n per neighbourhood = 14, range= 1–43). The odds of reporting depression at each follow up period were then analysed collectively using a binary logistic regression model adjusting for covariates and clustering by HABITAT neighbourhoods. The likelihood of reporting depression at T2 and/or T3 was also assessed in a separate model. We first estimated associations between three area level measures of objective crime (crime against the person, social incivilities and unlawful entry) and the odds of reporting depression conditional on covariates. Separate models were also used to test associations with perceived crime and neighbourhood disadvantage.

The adopted prospective study design enabled analyses that considered the time point at which a survey respondent may have reported depression (T2 or T3) from an initial starting outcome of being absent of depression (T1). The analyses also considered the temporal order of exposure to objective crime, neighbourhood disadvantage and perception of crime, however, a longitudinal study of change in depression in relation to changing exposures over time has not been undertaken and beyond the focus of this study.

To test for mediation, in separate models we then decomposed the effects of objective crime measures on depression by specifying perceived crime as an indirect effect. We then tested for mediation between neighbourhood disadvantage and depression by specifying the mediator as (1) perceived crime (2) crime against the person (3) social incivilities and (4) unlawful entry. Results are presented for crime against the person and neighbourhood disadvantage with the remaining mediation models involving social incivilities and unlawful entry provided in Supplement 1.

Indirect, direct, and total effects (reported on the log-odds scale) were estimated using the *ldecomp* package (Buis, 2010) in Stata version 16 (StataCorp., 2019), with bootstrapped standard errors (1000 repetitions) accounting for clustering of survey participants within HABITAT neighbourhoods and controlling for individual covariates. The approach uses two methods to estimate the indirect and direct effects, and these were then averaged into a single ratio for each effect as previously proposed (Jackson, Erikson, Goldthorpe, & Yaish, 2016). The *ldecomp* tool requires the variable whose direct effect we want to decompose (in our case the measure of objective crime or neighbourhood disadvantage) into an indirect and total effect be categorical whereas the variables through which the indirect effect occurs were continuous without assumption for normality. The outcome variable (depression) was binary (1= yes, 0 =no).

In prospective studies, in addition to exclusionary criteria, study attrition or non-response can become an issue of concern. Missing data for demographic and SEP variables were included as a 'missing in wave' category and were subsequently included in prospective mediation models. Pearson chi square analyses confirmed there were no significant differences between the T0-T2 sample ( $n=3120$ ) and the T0-T3 sample ( $n=2249$ ) on SEP variables or perceived crime. There was also no statistically significant change in the number of respondents across groups of neighbourhood disadvantage or objective crime after accounting for loss to follow-up.

Bivariate logistic regression models were also used to examine the likelihood of being lost to follow-up between T1 and T3 ( $n=650$ ). Based on variables included in the prospective analysis, those respondents significantly more likely to be lost to follow-up had lower household income, lower level of education, and occupational status including blue collar, unemployed or permanently unable to work ( $p<0.05$ ). Those living in neighbourhoods with the highest perceived crime and the most disadvantaged neighbourhoods were also more likely to drop out ( $p<0.05$ ). Those who reported depression in T2 were significantly more likely to be lost to follow-up in T3 ( $p<0.05$ ). These findings suggest bias towards the null, and that any finding indicating a positive association

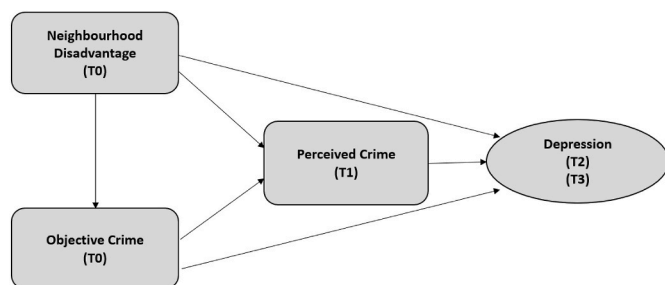


Fig. 2. Analytic framework.

Indicates key variables, time period of measurement and expected direction of relationships given selection criteria. Individual covariates (age, gender, length of residence, and measures of SEP including household income, education, and occupational status were measured at baseline (T0) only and not at subsequent waves. Those reporting depression at T1 were excluded from analysis.



between depression and these variables would likely be underestimated.

### 3. Results

The profile of the sample is shown in Table 1. The mean age of respondents was 54 years with a greater proportion of the sample being female. Approximately 7 percent of the sample were in the lowest household income category (<\$25,999) and over 30 percent had no education beyond high school. Almost 13 percent of the sample had retired from the workforce. Due to the selection criteria, the minimum length of residence in 2009 was 2 years. Approximately 10% of the sample lived in neighbourhoods experiencing the highest level of disadvantage.

Summary statistics of neighbourhood objective and perceived crime are reported in Table 2. During the 12-month period of crime reporting, the difference in the mean number of crimes across the lowest 20% of neighbourhoods versus the highest 20% of neighbourhoods was statistically significant for all crime types (p<0.001) with social incivilities being the most frequent type of crime recorded when comparing across the quintiles with the most crime. A significant difference was also evident for perceived crime across quintiles, although the mean score in the highest quintile was still relatively low (x = 4.1) on the perceived crime scale (0-10).

The proportion of those reporting depression at T2 was 5.93%

**Table 1**  
Sociodemographic profile indicating sample at 2-year and 5-year follow-up.

Category	T0-T2 Sample n (%)	T0 - T3 Sample n (%)
n (%)	3120 (100.0)	2249 (100.0)
Gender		
Male	1360 (43.6)	985 (43.8)
Female	1760 (56.4)	1264 (56.2)
Age category (years)		
40-44	334 (10.7)	226 (10.1)
45-49	627 (20.1)	454 (20.2)
50-54	680 (21.8)	503 (22.4)
55-59	644 (20.6)	469 (20.9)
60-64	594 (19.0)	415 (18.5)
65-69	241 (7.7)	182 (8.1)
Household income (Annual \$)		
>130,000	646 (20.7)	486 (21.6)
72,800-129,999	862 (27.6)	639 (28.4)
52,000-72,799	436 (14.0)	314 (14.0)
26,000-51,599	545 (17.5)	382 (17.0)
<25,999	222 (7.1)	164 (7.3)
Don't know	56 (1.8)	40 (1.8)
Refused	303 (9.7)	189 (8.4)
Missing in wave	50 (1.6)	35 (1.6)
Education		
Bachelor's degree or higher	1144 (36.7)	874 (38.9)
Diploma/Assoc. Degree	362 (11.6)	262 (11.7)
Certificate (trade/business)	539 (17.3)	402 (17.9)
None beyond School	1075 (34.5)	711 (31.6)
Occupation		
Manager/Professional	1084 (34.7)	845 (37.6)
White collar	658 (21.1)	449 (20.0)
Blue collar	375 (12.0)	255 (11.3)
Retired	395 (12.7)	283 (12.6)
Home duties	170 (5.5)	123 (5.5)
Unemployed	29 (0.9)	20 (0.9)
Permanently unable to work	31 (1.0)	16 (0.7)
Other	185 (5.9)	120 (5.3)
Missing in wave	193 (6.2)	138 (6.1)
Length of residence <sup>a</sup> (years)	13 (2-67)	14 (2-67)
Neighbourhood Disadvantage		
Q1 (Least)	889 (28.5)	661 (29.4)
Q2	763 (24.5)	543 (24.1)
Q3	588 (18.9)	424 (18.9)
Q4	569 (18.2)	408 (18.1)
Q5 (Most)	311 (10.0)	213 (9.5)

<sup>+</sup> percentile of disadvantage.  
<sup>a</sup> Median value (min - max)

**Table 2**  
Neighbourhood differences in objective and perceived crime.

Exposure	Quintile	Mean crime count <sup>a</sup>	p
Crime Against the person	Q1 (least)	1.0	P<0.001
	Q2	3.9	
	Q3	7.3	
	Q4	13.3	
	Q5 (most)	35.0	
Social Incivilities	Q1 (least)	2.5	P<0.001
	Q2	8.0	
	Q3	15.4	
	Q4	25.7	
	Q5	112.1	
Unlawful Entry	Q1 (least)	4.2	P<0.001
	Q2	12.2	
	Q3	22.2	
	Q4	34.9	
	Q5 (most)	64.5	
Perceived crime <sup>o</sup>	Q1 (lowest)	2.5	P<0.001
	Q2	2.8	
	Q3	3.1	
	Q4	3.4	
	Q5 (greatest)	4.1	

<sup>a</sup> Neighbourhood defined as 1 km network buffer <sup>o</sup> measured as mean level of perceived crime on scale 0-10.

(n=185), whereas at T3 this increased to 6.45% (n=145). After accounting for loss to follow up, 49.2% (59/120) of those who reported depression in T2 also reported depression again in T3. Thus, the incidence of new cases between T2 and T3 (a period of 3 years) was 4.04% (86/2129). The proportion of respondents reporting depression at any time over the 5-year follow up was 9.16% (206/2249).

Table 3 reports adjusted odds ratios and 95 percent confidence intervals for binary logistic regression models estimating the likelihood of reporting depression at T2, T3 and combined (T2 and or T3). Compared to living in neighbourhoods with the lowest crime against the person, those in the areas with highest crime against the person were significantly more likely to report depression at all time points of measurement. At 5-years of follow-up (T3), unlawful entry was significantly associated with depression, however the relationship was not graded across quintiles. There was limited evidence to support an association between social incivilities and depression, with only one significant finding across the three models. Neighbourhood perceived crime was associated with depression in the T2 model and the T2 and or T3 model, with those neighbourhoods with the highest neighbourhood perceived crime more likely to report depression than those neighbourhoods with the least perceived crime. High levels of neighbourhood disadvantage (Q4 & Q5) were consistently associated with depression in all three models with individuals living in the most disadvantaged neighbourhoods 2.32 times more likely to report depression than those in the least disadvantaged neighbourhoods.

Table 4 reports the decomposition of the effects of crime against the person and neighbourhood disadvantage on the log-odds of depression. All three models run at each time point were found to have significant total effects indicating the models were robust in their relationship with depression. Firstly, when the effect of crime against the person on depression was decomposed into a direct and indirect effect on depression, there was evidence to support a significant indirect effect of perceived crime on depression. Put differently, perceived crime mediated the association between crime against the person and depression. This indirect effect was evident at T2 and the combined model (T2 and or T3), with the combined model showing perceived crime explained 53.7% of the relationship between crime against the person and depression. No significant indirect effects were apparent when decomposing models of neighbourhood disadvantage indicating that neither crime against the person, nor perceived crime mediated the association between neighbourhood disadvantage and depression. Further analysis involving the decomposition of social civilities did not indicate

**Table 3**

Association between objective crime, perceived crime and neighbourhood disadvantage with depression over time.

Outcome: Depression		T2	p	T3	p	T2 and or T3 Adjusted OR (95 CI)	p
Exposure variables		Adjusted OR (95 CI)		Adjusted OR (95 CI)			
Crime Against the person	Q1	<i>referent</i>		<i>referent</i>		<i>referent</i>	
	Q2	1.21 (0.76–1.92)	0.414	1.02 (0.55–1.90)	0.952	0.89 (0.54–1.45)	0.634
	Q3	1.30 (0.83–2.02)	0.249	1.50 (0.87–2.60)	0.147	1.31 (0.85–2.01)	0.223
	Q4	1.03 (0.64–1.66)	0.895	1.30 (0.75–2.25)	0.352	1.09 (0.69–1.71)	0.722
	Q5	<b>1.60 (1.02–2.52)</b>	<b>0.043</b>	<b>1.71 (1.00–2.90)</b>	<b>0.048</b>	<b>1.61 (1.05–2.45)</b>	<b>0.027</b>
Social Incivilities	Q1	<i>referent</i>		<i>referent</i>		<i>referent</i>	
	Q2	0.92 (0.56–1.53)	0.755	1.22 (0.62–2.43)	0.564	1.09 (0.60–1.97)	0.776
	Q3	1.07 (0.69–1.65)	0.766	<b>2.04 (1.20–3.45)</b>	<b>0.008</b>	1.48 (0.96–2.27)	0.074
	Q4	1.07 (0.67–1.70)	0.774	1.49 (0.81–2.73)	0.203	1.27 (0.77–2.09)	0.341
	Q5	1.12 (0.71–1.78)	0.624	1.71 (0.94–4.11)	0.079	1.45 (0.91–2.29)	0.117
Unlawful Entry	Q1	<i>referent</i>		<i>referent</i>		<i>referent</i>	
	Q2	1.19 (0.78–1.82)	0.411	<b>2.27 (1.18–4.38)</b>	<b>0.015</b>	1.44 (0.87–2.39)	0.155
	Q3	<b>1.71 (1.12–2.60)</b>	<b>0.013</b>	<b>2.60 (1.29–5.25)</b>	<b>0.008</b>	<b>2.07 (1.21–3.54)</b>	<b>0.008</b>
	Q4	1.46 (0.95–2.24)	0.087	<b>2.26 (1.14–4.51)</b>	<b>0.020</b>	<b>1.70 (1.02–2.83)</b>	<b>0.040</b>
	Q5	1.09 (0.67–1.78)	0.715	<b>2.06 (1.04–4.07)</b>	<b>0.038</b>	1.43 (0.86–2.38)	0.170
Perceived crime	Q1	<i>referent</i>		<i>referent</i>		<i>referent</i>	
	Q2	0.80 (0.49–1.32)	0.386	1.25 (0.65–2.41)	0.495	0.91 (0.56–1.48)	0.704
	Q3	1.07 (0.68–1.67)	0.779	1.18 (0.63–2.24)	0.604	1.02 (0.64–1.64)	0.932
	Q4	1.17 (0.75–1.82)	0.491	1.51 (0.81–2.85)	0.198	1.27 (0.77–2.10)	0.345
	Q5	<b>1.58 (1.01–2.49)</b>	<b>0.047</b>	1.64 (0.84–3.20)	0.143	<b>1.76 (1.09–2.83)</b>	<b>0.021</b>
Neighbourhood Disadvantage	Q1	<i>referent</i>		<i>referent</i>		<i>referent</i>	
	Q2	1.17 (0.74–1.84)	0.507	0.98 (0.58–1.65)	0.926	0.94 (0.60–1.49)	0.801
	Q3	1.40 (0.91–2.18)	0.128	1.46 (0.86–2.51)	0.164	1.23 (0.81–1.88)	0.330
	Q4	<b>1.71 (1.11–2.64)</b>	<b>0.016</b>	<b>1.85 (1.04–3.29)</b>	<b>0.035</b>	<b>1.68 (1.07–2.65)</b>	<b>0.024</b>
	Q5	<b>2.19 (1.33–3.61)</b>	<b>0.002</b>	<b>2.20 (1.19–4.07)</b>	<b>0.012</b>	<b>2.32 (1.40–3.85)</b>	<b>0.001</b>

Binary logistic regression models are run separately for each exposure variable accounting for clustering of individuals within HABITAT neighbourhoods.

Quintiles are from lowest to highest crime, lowest to highest perceived crime and from least to most neighbourhood disadvantage.

Adjusted models include age, sex, household income, education, occupation and length of residence.

**Table 4**

Decomposition of the effects of crime against the person and neighbourhood disadvantage on the log-odds of depression.

	T2			T3			T2 and or T3		
	log odds	Bootstrap SE	p	log odds	Bootstrap SE	p	log odds	Bootstrap SE	p
<b>Neighbourhoods with highest crime against the person (Q5)<sup>a</sup></b>									
Total	<b>0.57</b>	<b>0.23</b>	<b>0.012</b>	<b>0.59</b>	<b>0.28</b>	<b>0.038</b>	<b>0.55</b>	<b>0.21</b>	<b>0.009</b>
Indirect (via perceived crime) <sup>c</sup>	<b>0.27</b>	<b>0.12</b>	<b>0.021</b>	0.21	0.14	0.131	<b>0.29</b>	<b>0.11</b>	<b>0.01</b>
Direct	0.31	0.26	0.234	0.38	0.30	0.200	0.25	0.24	0.282
Proportion mediated by perceived crime	0.465			0.355			0.537		
<b>Neighbourhoods experiencing most disadvantage (Q5)<sup>b</sup></b>									
Total	<b>0.97</b>	<b>0.27</b>	<b>0.000</b>	<b>0.84</b>	<b>0.32</b>	<b>0.008</b>	<b>0.94</b>	<b>0.26</b>	<b>0.000</b>
Indirect (via crime against the person) <sup>d</sup>	−0.04	0.09	0.410	−0.04	0.27	0.691	−0.06	0.07	0.434
Direct	<b>1.04</b>	<b>0.28</b>	<b>0.000</b>	<b>0.88</b>	<b>0.33</b>	<b>0.009</b>	<b>1.00</b>	<b>0.27</b>	<b>0.000</b>
Proportion mediated by crime against the person	−0.079			−0.044			−0.059		
<b>Neighbourhoods experiencing most disadvantage (Q5)<sup>b</sup></b>									
Total	<b>0.97</b>	<b>0.28</b>	<b>0.000</b>	<b>0.84</b>	<b>0.33</b>	<b>0.011</b>	<b>0.95</b>	<b>0.26</b>	<b>0.000</b>
Indirect (via perceived crime) <sup>c</sup>	0.17	0.25	0.492	0.10	0.32	0.759	0.27	0.25	0.275
Direct	<b>0.80</b>	<b>0.34</b>	<b>0.018</b>	0.74	0.43	0.082	<b>0.68</b>	<b>0.34</b>	<b>0.048</b>
Proportion mediated by perceived crime	0.175			0.117			0.285		

<sup>a</sup> Comparison group = Neighbourhoods with the least crime (Q1).<sup>b</sup> Comparison group = Neighbourhoods with the least disadvantage (Q1).<sup>c</sup> Measured using mean neighbourhood perceived crime score.<sup>d</sup> Measured using count of crimes against the person in 1km buffer. All models adjusted for age (54 years), sex (female), household income (\$52,000 – \$72,799), education (certificate), occupation (white collar) and length of residence (13 years).

significant total effects on the log odds of depression (Supplement Table S1). Decomposition of unlawful entry at T3 indicated a significant total effect on depression however neither a direct effect of unlawful entry nor an indirect effect of perceived crime was found to be significantly associated with depression. Similar to findings of decomposing neighbourhood disadvantage into an indirect effect of crime against the person, decomposition of neighbourhood disadvantage into a direct effect and indirect effect of either social incivilities or unlawful entry did not find evidence of mediation (Supplement Table S1).

#### 4. Discussion and conclusion

A key part of the socio-ecological determinants of mental health research agenda is understanding the mechanisms by which neighbourhood exposures may lead to depression. How area level crime influences depression remains to be fully understood (Baranyi et al., 2021). This prospective study aimed to build on previous research by clarifying relationships with depression in the Australian context and investigating potential mediating pathways involving objectively measured types of crime, a self-reported aggregate measure of perceived crime and neighbourhood disadvantage, all while aiming to minimise

self-selection and same source bias.

Few studies have analysed different types of crime in relation to depression. Our contribution to the existing literature on crime and depression includes evidence that supports different types of crime are not uniformly associated with depression. Our first hypothesis that relationships between crime and depression will vary upon the particular type of crime under study was supported by evidence for a relationship between neighbourhoods with high levels of crime against the person on depression over time, as well as unlawful entry, whereas limited evidence was found for a relationship with social incivilities. It is possible that neighbourhoods experiencing higher levels of crimes against the person as opposed to social incivilities, promote avoidance behaviours such as social isolation and reduced neighbourhood physical activity particularly among older citizens (Portacolone, Perissinotto, Yeh, & Greysen, 2018; Tamura et al., 2020), leading to depression via a biological stress mechanism. We were not able to explain the non-linear increase in odds of depression across quintiles of unlawful entry at 5-years (T3) in comparison to 2-years (T2). Events during mid-life and onwards including parenting, and retirement may result in greater connection with the local neighbourhood (e.g. rise in local social connections or reduced movement beyond local neighbourhood) which may increase indirect exposure to crime over time.

In comparison to our findings on crime type, one previous U.S. study found effects specific to violent crime and no other types, whereby adolescents living in areas with higher levels of violent crime were more likely to experience higher levels of depressive symptoms over time, but only if they engaged in higher levels of rumination (Gepty, Hamilton, Abramson, & Alloy, 2019). From a policy perspective, this study highlights the importance of addressing the indirect impact of crime on depression and the need to consider both community- and individual-level factors to address mental health.

Past systematic reviews have called for evidence on the mechanisms or pathways that lead to depression (Barnett et al., 2018). Our study found evidence for a mediating effect of perceived crime on the association between crime against the person and incidence of depression in two out of three, time dependent prospective models. This finding supported our second hypothesis and is important in the context of research into mental health to date that has rarely reported on interrelationships between objective and perceived measures of crime and safety in the one study.

Our findings also confirmed a strong direct effect of living in an area of neighbourhood disadvantage and incidence of depression over time, accounting for individual demographics and SEP. This finding aligns with past meta-analyses which include similar follow up periods (Barnett et al., 2018; Richardson et al., 2015). These findings contribute to our existing understanding of crime and depression by suggesting that in a large urbanised Australian capital city, the effect of neighbourhood disadvantage on incident depression does not work indirectly through objective crime or perceived crime. This was not supported by a previous US study that found that violent crime (homicide rate) partially mediated the association between poverty and depressive symptoms amongst an older cohort (Joshi et al., 2017). Higher levels of poverty and homicide experienced in New York City neighbourhoods compared to the city of Brisbane may be one reason for this contrast in findings. The spatial units adopted are important in understanding the relationship between crime and mental health, with some evidence that microgeographic scales (street block level, 100m) are also important (Cuartas & Roy, 2019; Weisburd et al., 2018). Another longitudinal study from the United Kingdom found property crime to have the greatest effect on depression symptoms over time when it occurred within residents' immediate neighbourhood (local authority), whereas violent crime was also relevant in a larger spatial area around their habitation potentially explained by commuting and socialising outside of their immediate neighbourhood (Dustmann & Fasani, 2016). There may be no fixed spatial scale applicable in all settings and for all health conditions. For example, in settings, where the events of interest – such

as incivilities – are more common, analysts may prefer to use a smaller spatial unit whereas a larger spatial reference unit may be more appropriate if the events are rare such as murder. In future studies, recently developed statistical techniques such as Multi-scale Geographic Weighted Regression (MGWR) may be also be useful to address the issue of varying scales of influence across space (Fotheringham, Yang & Kang, 2017).

Our findings suggest other mediating factors of neighbourhood disadvantage may be at play such as the availability of physical and social resources (Baranyi et al., 2019; Generaal et al., 2019; Kubzansky et al., 2005). One review of the effect of neighbourhood factors on depression suggested individual mechanisms such as sense of control or powerlessness and formation of supportive social networks may mediate the effects of neighbourhood disadvantage on depression (Blair et al., 2014). Recent studies point to other potential ecological mediators of neighbourhood disadvantage such as poor housing quality (Kim, Jeong, Jang, Park, & Jang, 2021) and lack of functional green space (Astell-Burt & Feng, 2019), with further research in this area needed. Such research can help tailor interventions that engage both community and individual level approaches to address depression.

Our study endeavoured to improve the validity of a perceived crime measure by aggregating a perceived crime scale to the neighbourhood level as recommended by Chum and colleagues (Chum, O'Campo, et al., 2019). Adopting this approach as well as ensuring a temporal difference between data collected on the occurrence of crime (T0) and perceived crime (T1), we argue, helps to strengthen the robustness of the study findings by minimising potential bias. This study, however, is not without its limitations. For example, our binary self-report measure of depression does not reflect the severity of the depression. A scale indicating severity of depressive symptoms such as the commonly used Center for Epidemiological Studies-Depression measure (CES-D) (Radloff, 1977) was not available, nor were we able to account for whether a respondent was themselves a victim or witness to a crime which has been shown to influence mental health outcomes. (Cornaglia, Feldman & Leigh, 2014; Grinshteyn, Xu, Manteuffel, & Ettner, 2018). It is also quite possible that many individuals experiencing depression in the population go undiagnosed by a health professional. Thus the estimates of depression in our study are conservative and the actual effect of crime and neighbourhood disadvantage on depression may in fact be greater.

This study did not measure the change in exposures over time which opens the possibility of some neighbourhoods experiencing changes in levels of disadvantage over time. For example, the fact that incidence of objective crime was measured for a single point in time means that potential fluctuations over more extended periods, which may influence perceptions, remain to be explored. The process of neighbourhood change can potentially be slow and thus rapid changes in mental health outcomes may be more likely to be seen amongst those relocating to new environments with different characteristics (Baranyi et al., 2020). Opportunities for experimental study designs in this field should be taken advantage of (Baranyi et al., 2020; Hooper, Foster, Knuiman, & Giles-Corti, 2020; Ram et al., 2020). Longitudinal research should consider repeated measurements of exposures and depression outcomes over the life course.

Finally, a strength of this study was its use of reported crime data geocoded to the street address which enabled the assignment of crimes to individual buffers rather than the adoption of administrative boundaries. The finding reported at the 1 km network buffer scale support the limited evidence available that has found associations with increased specificity of measurement of crime exposure beyond the aggregation of administrative boundaries (Goldberg, White & Weisburd, 2019; Weisburd et al., 2018). In Australian and other jurisdictions, more authorities should consider making geocoded crime data available for research purposes to enable spatial relationships with mental health outcomes to be uncovered. The release of such detailed crime data could enable more standardised methods useful in meta-analysis of the impact of crime exposure on mental health across different study regions which is

critical for understanding what prevention strategies might be most effective and where.

### Author statement

Concept and design: All authors, Acquisition, analysis, or interpretation of the data: All authors, Statistical analyses: VL, Drafting of the manuscript: VL, Critical revision of the manuscript for important intellectual content: All authors

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### Ethical statement

HABITAT received ethical clearance from the Queensland University of Technology Human Research Ethics Committee (Ref. Nos. 3967H & 130000161).

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2022.101190>.

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