



Reciprocal associations of adolescent perceptions of neighbourhood safety and problem behaviour

Emily Midouhas*, Maria Sifaki, Helen Lai, Eirini Flouri

Department of Psychology and Human Development, UCL Institute of Education, University College London, 25 Woburn Square, London WC1H 0AA, UK



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ABSTRACT

Adolescents who perceive their neighbourhoods as unsafe are more likely to display emotional and behavioural problems. But, little is known about whether perceptions of safety and problem behaviour influence each other. This study explored the reciprocal relationships between perceptions of neighbourhood safety and emotional and behavioural problems in adolescence in a general population sample. It also explored two mediators of these associations (personal victimisation and risky behaviour). Data were analysed on 9,200 adolescents at ages 11 and 14 participating in the UK's Millennium Cohort Study. Bidirectional associations were found between perceptions of safety and all domains of problem behaviour. Personal victimisation partially mediated the reciprocal relationships between neighbourhood safety and all problem domains. Risky behaviour partially mediated some of these paths. The findings suggest that, in adolescence, perceived neighbourhood safety and emotional and behavioural problems mutually influence each other, partly due to experiences of victimisation and risky behaviour.

Adolescence is a period of development marked by substantial physical, social and biological changes. It is a time of shifting orientation within the wider social environment, as adolescents increasingly spend more time with peers and engage more with their neighbourhood environments than younger children do (Leventhal and Brooks-Gunn, 2000, Sampson et al., 2002). During this developmental phase, adolescents are especially susceptible to stress and mental health problems. Neighbourhood environments have been associated with adolescent mental health in numerous studies (Feng and Astell-Burt, 2017, Li et al., 2018, McElroy et al., 2019, Mueller et al., 2019). Reflecting Diez Roux and Mair's (2010) conceptualisation of how neighbourhoods impact health outcomes, research supports the role of both social neighbourhood factors such as social cohesion, disorder and socio-economic composition (McElroy et al., 2019, Mueller et al., 2019) and physical neighbourhood characteristics including green space, air quality and density of housing (Feng and Astell-Burt, 2017, Li et al., 2018, Diez Roux and Mair, 2010, Roberts et al., 2019, Tillmann et al., 2018).

One aspect of the neighbourhood social environment that may be particularly important for adolescent mental health, especially for individuals living in socio-economically disadvantaged or socially disorganised areas, is safety. The majority of research into neighbourhood safety and adolescent mental health has explored resident ('subjective') perceptions rather than objective measures of safety (e.g., crime rates, level of violence). This is perhaps due to the fact that historically it has been difficult to obtain neighbourhood-level crime data that is compara-

ble across neighbourhoods. Measuring subjective perceptions of safety and violence in the neighbourhood is convenient but also defensible (Pratt et al., 2019). Compared with objective measures, subjective assessment of safety may more closely reflect adolescents' appraisals of threats in their environment which may trigger psychological problems.

Moreover, some research has found that individual perceptions of neighbourhood safety, violence and disorder may be more important for adolescent mental health than objective levels of neighbourhood crime (Allen and Goldman-Mellor, 2018, Goldman-Mellor et al., 2016, Sampson and Raudenbush, 2004). For example, Goldman-Mellor et al. (2016) showed that, in a large, population-based study in California, adolescents who viewed their neighbourhood to be unsafe were around 2.5 times more likely to experience recent serious psychological distress relative to those who reported living in safe neighbourhoods. Conversely, adolescents in objectively high-crime areas were no more likely to be psychologically distressed than their counterparts in low-crime areas. Moreover, Allen and Goldman-Mellor (2018) found that subjective perceptions of safety were associated with risk of suicidal ideation and attempt in adolescents but objective indicators (i.e., levels of crime and property crime) were not. Therefore, gaining adolescents' perspectives of their neighbourhood environments and exploring them alongside 'objective' area measures may help us to understand better their importance for their mental health.

Studies of adolescent perceptions of safety, violence and disorder have shown links with depressive symptoms (Dawson et al., 2019, Hill et al., 2005, Ross and Mirowsky, 2009, Steptoe and Feld-

* Corresponding author.

E-mail address: emily.midouhas@ucl.ac.uk (E. Midouhas).

man, 2001), risk of major depressive disorder among African American males (but not females or Black Caribbean males or females) (Assari and Caldwell, 2018), aggression (Fite et al., 2010), emotional problems (Meltzer et al., 2007), behavioural problems (Singh and Ghandour, 2012), suicidal ideation and attempt (Fowler et al., 2009) and general psychological distress (Mueller et al., 2019, Goldman-Mellor et al., 2016). As shown in a meta-analysis by Fowler et al. (2009), however, in adolescence, associations are generally moderate in size. For example, Cohen's d is 0.45 for the relationship between perceived violence and safety in the community and psychological distress. The majority of the aforementioned studies were cross-sectional and did not use general population data, thereby limiting the rigour of the research and the generalisability of the findings.

Theorised pathways

Another limitation of the research to date is that the pathways linking perceptions of safety and mental health in adolescence are not well examined. Individuals who perceive their neighbourhood to be stressful and threatening may be more likely to experience regular feelings of worry, fear and isolation (Choi and Matz-Costa, 2018, Cutrona et al., 2006), due to viewing neighbours as being untrustworthy or dangerous and feeling they lack personal control. Moreover, they are more likely to report greater negative affect following exposure to daily stressors, minor or major (Scott et al., 2018). And they are less likely to walk or visit parks in the area and be physically active outdoors (Guo et al., 2018). All of these factors have been related to elevated mental health problems (Ross and Mirowsky, 2009, Ross and Mirowsky, 2001).

According to social disorganisation theory (Shaw and McKay, 1942, Wilson, 1987) physical and social 'cues' of disorder in the neighbourhood could also make adolescents feel unsafe. An unsafe neighbourhood may have social and physical characteristics that signify the disintegration of order in the community. In public places, social cues such as loitering, gang activity, hostile arguing and drug dealing, as well as physical ones including presence of abandoned housing and cars, graffiti and litter in the streets, suggest there is a lack of social control and low regulation of behaviour in the neighbourhood (Skogan, 1990). This can facilitate crime and fear of crime, low confidence in police, as well as a host of other social and economic problems (Diez Roux and Mair, 2010, Ross and Mirowsky, 2009, Ross and Mirowsky, 2001, Gracia and Herrero, 2006, Sampson et al., 1997, Sampson and Wilson, 1995). By contrast, neighbourhoods higher in social capital and social cohesion may have greater resources that residents can access such as norms of reciprocity, trust in others and civic participation (Poortinga, 2006, Subramanian et al., 2003). In such areas, residents may be more apt to trust their neighbours and may feel safer. Neighbourhood social disorganisation has indeed been linked to psychological distress and depression in both adults and adolescents (Wight et al., 2006, Hurd et al., 2013) as well as biological markers of stress in adolescents (Dulin-Keita et al., 2013).

Individuals who report living in unsafe areas may also be more likely to experience personal victimisation such as being hit with a weapon and physically or sexually assaulted. And one study showed that adolescents who have experienced gun violence in particular (compared to violence related to drug activity) were especially likely to report their area as being unsafe (Zuberi, 2016). Being a witness of a crime or knowing someone who was a victim was also related to an increased likelihood of rating one's neighbourhood as being unsafe (Zuberi, 2016). A cross-sectional study of 2,482 adults in Illinois (Ross and Mirowsky, 2001) found that around 10 percent of the relationship between perceived neighbourhood disorder and anxiety, anger and depression was due to personal victimisation. In turn, experiences of victimisation have been linked to psychological distress in adolescence. For example, in a US adolescent community sample, Slopen et al. (2012) demonstrated that witnessing crime and being a victim in the neighbourhood (e.g., being chased to hurt, physically assaulted or attacked with a weapon)

were linked to an elevated risk of major depressive disorder and generalised anxiety disorder. Furthermore, adolescents with poor mental health may be more susceptible to being victimised (Arseneault et al., 2010, Fisher et al., 2012) and, as mentioned previously, may view their neighbourhoods as more threatening, regardless of actual levels of crime (Fowler et al., 2009, Slopen et al., 2012, Chung et al., 2013, Mrug and Windle, 2010).

Additionally, individuals who perceive their neighbourhoods as unsafe may be more apt to engage in risky behaviour including shoplifting, drawing graffiti and vandalism. Although adolescence is a time of heightened vulnerability to risky behaviour to begin with (Steinberg, 2007), youth living in unsafe areas where they may be exposed to violence and crime may engage early in risky behaviours as a way of coping with the stress from such exposures (Copeland-Linder et al., 2010, Fagan et al., 2015, Sampson et al., 2008, Sanbonmatsu et al., 2011, Tyler and Bersani, 2008). Other research finds links with more varied or more serious risky behaviour. In a recent study, for example, Santiago et al. (2017) found that neighbourhood safety (measured objectively, however) was related to risky behaviours (running away from home, using aggressive or violent behaviour and consuming marijuana) among African American youth. The authors suggested that, in neighbourhoods with more crime, there may be weaker collective social norms discouraging violence. In turn, risky behaviour is strongly related to mental health problems in teens (Katon et al., 2010, Keyes et al., 2007). Mental health problems have been shown to predict the likelihood of engaging in risky behaviour, but also the act of doing so may cause adolescents to perceive their neighbourhoods as more unsafe.

Our study

An important question that remains unanswered in the studies linking adolescents' perceptions of safety in the neighbourhood to their mental health is whether adolescents' neighbourhood perceptions affect their mental health, whether their mental health influences their perceptions of their neighbourhoods, or whether both influence each other. Although most studies to date have explored the link from perceptions to problems, only two studies (Chung et al., 2013, Fagg et al., 2008), to our knowledge, examined the role of mental health in neighbourhood perceptions of adolescents. Both studies found that adolescents with greater mental health problems viewed their neighbourhoods as being worse than those with fewer problems. Having mental health problems such as depression may cause one to be more negative about one's life circumstances and the environments one experiences, which could result in a poorer perception of one's area despite its actual (objective) characteristics. However, no study, to our knowledge, has examined the *bidirectional associations* between area safety perceptions and adolescent mental health. This would allow us to get closer to understanding the direction of these associations. In addition, as mentioned, nearly all of the existing studies of safety perceptions and mental health are cross-sectional. Finally, further research is needed on personal victimisation and risky behaviour as mediators of the associations between neighbourhood safety perception and adolescent mental health.

Our study used two waves of longitudinal data and a cross-lagged design to explore the bidirectional effects of neighbourhood safety perception and mental health, operationalised here as problem behaviour, in adolescence (at ages 11 and 14 years), utilising data from the UK's Millennium Cohort Study (MCS). It also tested for mediation of the cross-lagged relationships by personal victimisation and risky behaviour. Our control variables were known confounders of the association between problem behaviour and neighbourhood perception as well as neighbourhood selection factors. Selection into neighbourhoods (Harding, 2003) occurs when the selection mechanism into areas is not independent from the outcome studied. For example, families may be more likely to live in unsafe areas if they come from more disadvantaged backgrounds (Keyes et al., 2007, Wilson et al., 2004). Adolescents from disadvantaged

families are also more likely to show problem behaviour (Bradley and Corwyn, 2002). Therefore, in all models, we adjusted (at baseline) for mother's educational attainment, family socio-economic disadvantage, maternal psychological distress, mother's single parent status and ethnicity. We also adjusted for gender and exact age. Lastly, in a supplementary analysis, we checked whether the associations of perceived safety and problem behaviour were robust to adjustments for the objective neighbourhood social environment.

Method

Study sample

We used secondary data from the Millennium Cohort Study (MCS) (www.cls.ioe.ac.uk/mcs), a longitudinal survey of children born in the UK over 12 months from 1 September 2000. To date, seven sweeps (waves) of data have been carried out. A total of 19,519 children (19,244 families) participated in at least one of these seven sweeps. The MCS sample is disproportionately stratified, firstly by country, and then type of electoral ward¹. The sample design over-represented families living in areas of high child poverty, areas with high proportions of ethnic minority populations across England and the three smaller UK countries. The MCS families were sampled from 338 electoral wards across the UK. Ethical approval was gained from NHS Multi-Centre Ethics Committees, and parents (and children from age 11 years) gave informed consent before interviews took place.

MCS children were around 9 months old at Sweep 1, and 3, 5, 7, 11, 14 and 17 years old at Sweeps 2-7, respectively. We used data from the fifth and sixth sweeps of the MCS (at ages 11 and 14, respectively). Our analytic sample ($n = 9,200$) comprises singleton and, in the case of twins or triplets, first born cohort members with data at both ages 11 and 14 on our two main variables, neighbourhood safety perception and problem behaviour, and with data on the covariates. Our 'non-analytic' sample comprises those present in either the fifth or sixth sweep who were not included in the analytic sample ($n=4,703$).

Measures

Emotional and behavioural problems (problem behaviour) were measured at ages 11 and 14 with the parent-reported Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997). The SDQ is a short, reliable and widely-used behavioural screening tool. It consists of 25 items, grouped into 5 scales (of 5 items each): emotional symptoms, conduct problems, hyperactivity/inattention, peer problems and prosocial behaviour (not included in this study). Each item is scored on a 3-point scale of 0 (*not true*), 1 (*somewhat true*), and 2 (*certainly true*). Scores for each scale may range 0-10. Cronbach's alphas for ages 11 and 14, respectively, were .70 and .73 for emotional symptoms, .61 and .63 for conduct problems, .77 and .78 for hyperactivity and .63 and .63 for peer problems. Thus, in our sample internal consistency was in line with other SDQ research (Stone et al., 2010).

Perceived neighbourhood (low) safety was measured with one item at ages 11 and 14 that asked adolescents to report how safe the area around their home was to play in. They answered on a 4-point scale from "very safe" to "not at all safe". A higher perceived neighbourhood safety score suggests a less safe area.

Our two proposed mediators were personal victimisation and risky behaviour. *Personal victimisation* was assessed at age 14 with 5 questions that asked adolescents to indicate whether or not they had experienced each of the following incidents in the past 12 months: Being threatened, being physically assaulted, being hit with a weapon, having their possessions stolen and being sexually assaulted. A total victimisation score was created by summing the 5 responses together. This total score therefore represents the total number of incident types experienced by the adolescent in the past year, ranging 0-5.

Risky behaviour was measured at age 14 with 5 questions that asked adolescents to state whether or not they had engaged in each of the following types of risky behaviour in the past 12 months: 1) Been noisy or rude in a public place, 2) taken something from a shop without paying for it, 3) written things or sprayed paint on a building, 4) damaged anything in a public place on purpose and 5) stayed out without parental permission. A total score was created representing the total number of risky behaviours in the past year that the adolescent engaged in, ranging 0-5.

We adjusted our models for child- and parent/family-level covariates that could be possible confounders and/or associated with selection bias into neighbourhoods. The child-level covariates were: *Ethnicity* (based on the UK census official categories: White, Indian, Pakistani/Bangladeshi, Black, Mixed and Other), *gender* and *age*. The parent/family-level covariates (all measured at age 11 except for maternal education) were: *Maternal education* (whether the mother attained a university degree or not by child's age 14), *maternal psychological distress* ($\alpha=.88$), assessed with the 6-item Kessler scale (Kessler et al., 2003), *single-parent status* and *family socio-economic disadvantage*, measured with a summary of four binary items indexing the family's economic and material deprivation (Malmberg and Flouri, 2011): 1) Overcrowding (>1.5 people per room excluding bathroom and kitchen), 2) not owning their home, 3) in receipt of means-tested income support and 4) living below the poverty line (set for equivalised net family income at 60% of the national median household income).

Analytic approach

All analyses were run in STATA 15.0. First, we explored the differences between the analytic sample ($n=9,200$) and the non-analytic sample ($n=4,703$) in the study variables. Next, we estimated the correlations among the study variables in the analytic sample. To investigate whether neighbourhood safety perceptions predict adolescent problem behaviour, and vice versa, at ages 11 and 14, we estimated cross-lagged path models (Fig. 1) with manifest variables, adjusting for all covariates on the age 14 safety perception and problem behaviour variables (Model 1). We used a Wald test to examine which cross-lagged effects were stronger. We then added experience of victimisation and tested if it mediates any of the cross-lagged paths (Model 2). Then we added risky behaviour and tested if it mediates any of the cross-lagged paths (Model 3). Personal victimisation and risky behaviour were tested in separate models but are represented together in Fig. 1.

We also conducted a robustness check by adjusting additionally for an objective measure of neighbourhood socio-economic conditions to see whether the perception of the neighbourhood context had an effect above and beyond the 'objective' context. We adjusted for *neighbourhood median income* for each Lower layer Super Output Area (LSOA¹) (at baseline, when the adolescent was age 11) with data from Experian, drawn from multiple sources, including the Census, market research and public sector datasets (Experian 2011). For age 11 (sweep 5), the 2010 neighbourhood median income estimates were used and these were converted to deciles across all LSOAs. We used the Experian median household income data because it is a measure for LSOAs across all four countries in the UK. The Index of Multiple Deprivation, commonly used to measure area deprivation in the UK, has different measures for each of the four countries that cannot be used in the same analysis. The Experian measure has been associated with both externalising and internalising problems of children in the MCS (Flouri et al., 2015).

As part of the robustness check, we also adjusted for whether the adolescent's family changed address between ages 11 and 14. A change of address could mean a change of area, which could result in a change in one's perception of safety around their home. House moves have

¹ LSOAs cover around 1,500 inhabitants, with boundaries drawn to maximise social homogeneity.

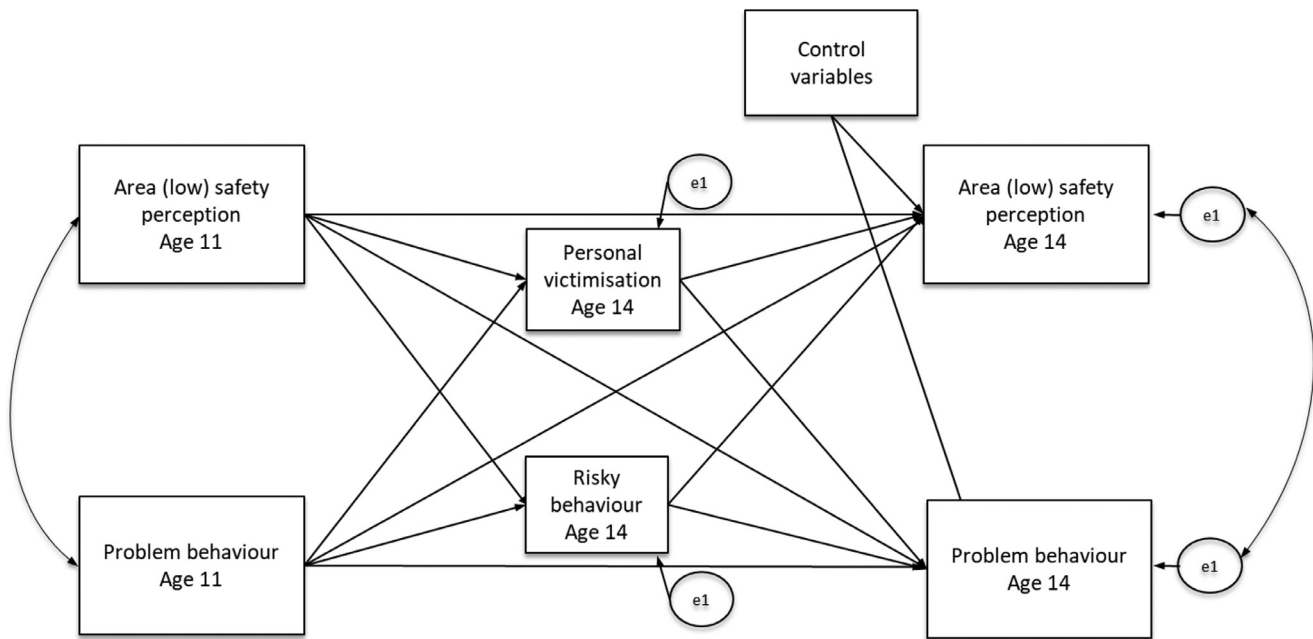


Fig. 1. Cross-lagged model of neighbourhood safety and problem behaviour with proposed mediators (personal victimisation and risky behaviour). Control variables are family socio-economic disadvantage (at adolescent's age 11), maternal education by age 14, single parent status (age 11), maternal psychological distress (age 11), adolescent's age in months, gender, ethnicity (Mixed, Indian, Pakistani/Bangladeshi, Black or Other, compared to White) and MCS strata.

also been related adversely to emotional and behavioural problems (Gambaro and Joshi, 2016).

All models accounted for the stratified sample design of MCS, indicating the areas (wards) from which families were sampled in the first sweep (age 9 months). There were nine strata: England-disadvantaged, England-advantaged, English-ethnic, Wales-advantaged, Wales-disadvantaged, Scotland-advantaged, Scotland-disadvantaged, Northern Ireland-advantaged and Northern Ireland-disadvantaged.

Results

Bias analysis and descriptives

Table 1 includes the descriptive statistics for the analytic ($n=9,200$) and the non-analytic sample ($n=4,703$). There were several differences between the two samples revealing a more privileged analytic sample. For example, there was a higher proportion of university-educated mothers and a lower proportion of single-parent families in the analytic sample. Furthermore, families in the analytic sample had lower psychological distress and socio-economic disadvantage. At both sweeps, participants in the analytic sample experienced significantly fewer emotional and behavioural difficulties in all domains and reported higher neighbourhood safety. There was no difference in risky behaviour in the two samples but participants in the analytic sample were more likely to have been a victim.

Correlations

Table 2 shows the correlations between the main variables in the study - neighbourhood safety, the four SDQ domains and the proposed mediators (personal victimisation and risky behaviour). As expected, significant but weak associations were identified for neighbourhood safety and most SDQ domains at ages 11 and 14 years, ranging .08-.10. Victimization and risky behaviour were both associated weakly with neighbourhood safety and the SDQ domains ranging .02-.15. However, age 14 risky behaviour was not significantly correlated with age 11 neighbourhood safety, age 14 emotional symptoms and age 11 peer problems. Age 14 risky behaviour was significantly correlated with age

14 peer problems, but its correlation coefficient was negative, indicating that children who demonstrated more risky behaviour were less likely to exhibit peer problems.

Cross-lagged path analysis

All five cross-lagged models, adjusted for covariates, fitted the data very well, with CFI values at or above .96, TLI values at or above .86 and RMSEA values below .04.

Model 1: Fully adjusted cross-lagged path model

Table 3 displays the results of the fully adjusted cross-lagged model for each SDQ domain. Living in a less safe neighbourhood at age 11 was a significant predictor of a higher number of all four problem types at age 14. Additionally, all four problem types at age 11 significantly predicted living in a less safe neighbourhood at age 14. For emotional symptoms and conduct problems, a Wald test revealed that the effect of safety on symptoms was larger than that of symptoms on safety (emotional symptoms: $\chi^2=176.92$, $df=1$, $p<.001$; conduct problems: $\chi^2=551.83$, $df=1$, $p<.001$). For hyperactivity and peer problems, conversely, a Wald test showed that symptoms had a larger effect on safety than safety did on symptoms (hyperactivity: $\chi^2=338.57$, $df=1$, $p<.001$; peer problems: $\chi^2=323.72$, $df=1$, $p<.001$).

Model 2: Testing for mediation by experiences of victimisation

Experiences of victimisation partially mediated all cross-lagged associations for each SDQ domain. Tables 4-7 contain the coefficients of indirect, direct and total effects for all SDQ domains. For example, being a victim partially mediated the effect of (low) neighbourhood safety at age 11 on the increase of emotional symptoms at age 14. Both the total effect ($\beta=0.04$, $p<.001$) and the indirect effect ($\beta=0.005$, $p<.001$) were significant. Being a victim also mediated partially the association between emotional symptoms at age 11 and lower neighbourhood safety at age 14 (Fig. 2). Both the total effect ($\beta=0.03$, $p<.001$) and the indirect effect ($\beta=0.004$, $p<.001$) were significant.

Table 1
Descriptives of study variables in the analytic sample and in the non-analytic sample.

Categorical variables	Analytic Sample (N=9,200)		Non-Analytic Sample (N=4,703)		χ^2 ^a
	N	%	n	%	
Girl	4674	50.8	2181	46.4	24.43***
<i>Ethnicity</i>					313.31***
White	7931	86.2	3523	75.0	274.17***
Mixed	251	2.7	152	3.2	
Indian	210	2.3	146	3.1	
Pakistani/Bangladeshi	469	5.1	545	11.6	
Black	235	2.6	234	5.0	
Other ethnic group	104	1.1	99	2.1	
Mother is university-educated by child's age 14	2315	25.2	614	13.1	
Mother is single parent at child's age 11	2110	22.9	773	30.7	64.96***
<i>Continuous variables</i>	N	Mean (SD)	n	Mean (SD)	t ^b
<i>Age 11</i>					
Neighbourhood safety	9200	1.80 (0.64)	3553	1.85 (0.67)	3.51***
Emotional symptoms	9200	1.79 (1.94)	3587	2.08 (2.10)	7.17***
Conduct problems	9200	1.28 (1.49)	3590	1.68 (1.75)	12.19***
Hyperactivity	9200	2.95 (2.38)	3562	3.58 (2.64)	12.26***
Peer problems	9200	1.26 (1.60)	3595	1.67 (1.87)	11.41***
Maternal psychological distress	9200	3.87 (4.28)	2910	4.73 (4.88)	8.50***
Socio-economic disadvantage	9200	0.16 (0.24)	4078	0.28 (0.30)	22.71***
<i>Age 14</i>	N	Mean (SD)	n	Mean (SD)	t ^b
Neighbourhood safety	9200	1.76 (0.58)	2171	1.82 (0.60)	4.41***
Emotional symptoms	9200	1.95 (2.09)	2127	2.47 (2.28)	9.64***
Conduct problems	9200	1.32 (1.55)	2129	1.84 (1.89)	11.83***
Hyperactivity	9200	2.84 (2.34)	2122	3.66 (2.54)	13.66***
Peer problems	9200	1.64 (1.77)	2132	2.20 (1.95)	12.19***
Risky behaviour	9200	0.29 (0.69)	1937	0.30 (0.71)	0.43
Personal victimisation	9200	0.79 (0.97)	1969	0.70 (0.96)	3.67***
Child's age in months	9200	13.76 (0.45)	2514	13.81 (0.44)	4.66***

Notes:
^a Pearson's Chi-Square;
^b Independent samples t-test.

Table 2
Correlations among the main variables in the analytic sample (n = 9,200).

	1	2	3	4	5	6	7	8	9	10	11	12
1. S6 Emotional	1.000											
2. S5 Emotional	.507**	1.000										
3. S6 Conduct	.318**	.227**	1.000									
4. S5 Conduct	.254**	.312**	.573**	1.000								
5. S6 Hyperactivity	.311**	.250**	.500**	.419**	1.000							
6. S5 Hyperactivity	.235**	.317**	.385**	.492**	.652**	1.000						
7. S6 Peer	.418**	.310**	.275**	.255**	.286**	.265**	1.000					
8. S5 Peer	.293**	.401**	.231**	.298**	.231**	.293**	.507**	1.000				
9. S6 NS	.090**	.077**	.063**	.060**	.077**	.071**	.099**	.090**	1.000			
10. S5 NS	.101**	.086*	.090**	.066**	.081**	.080**	.108**	.086**	.249**	1.000		
11. S6 Risky behaviour	.013	.009	.142**	.105**	.134**	.082**	-.021*	.005	.022	.074**	1.000	
12. S6 Victimisation	.075**	.050**	.124**	.108**	.113**	.091**	.145**	.119**	.062**	.108**	.211**	1.000

Notes: * $p < .05$ (2-tailed). ** $p < .01$ (2-tailed). S5 and S6 refer to MCS sweeps 5 (age 11) and 6 (age 14), respectively. Emotional = Emotional symptoms, Conduct = Conduct problems, Peer = Peer problems, NS = Neighbourhood safety, RB = Risky behaviour.

Model 3: Testing for mediation by risky behaviour

Risky behaviour partially mediated the effect of (low) neighbourhood safety at age 11 on the increase of conduct problems at age 14 and the association between conduct problems at age 11 and reduction in perceived neighbourhood safety at age 14. Tables 4–7 contain all the coefficients of indirect, direct and total effects. Fig. 3 shows the coefficients for the model of conduct problems. Risky behaviour also mediated the effect of hyperactivity problems at age 11 on reducing perceived neighbourhood safety at age 14, but not the reverse association. On the other hand, risky behaviour mediated the pathway from low neighbourhood safety at age 11 to increased peer problems at age 14, but not the reverse.

Risky behaviour did not mediate either cross-lagged path for emotional symptoms.

Robustness checks

We ran the three models again adjusting for neighbourhood median income and residential mobility. Results were robust to these adjustments (Tables S1–S5) with two exceptions: 1) The direct cross-lagged effect of hyperactivity on neighbourhood safety in Model 2 (which modelled personal victimisation as mediator) was attenuated, and 2) the direct cross-lagged effect of conduct problems on neighbourhood safety in Model 3 (which modelled risky behaviour as mediator) was attenuated. Model 1 (Table S1) retained all significant cross-lagged effects and

Table 3

Results (unstandardised coefficients, standard errors and standardised coefficients) of cross-lagged models of neighbourhood safety and problem behaviour (Model 1).

Regression paths	Emotional symptoms			Conduct problems			Hyperactivity			Peer problems		
	b	SE	β	b	SE	β	b	SE	β	b	SE	β
Stability in neighbourhood safety over time												
Age 11 → Age 14	0.20***	0.01	0.23	0.21***	0.01	0.23	0.21***	0.01	0.23	0.21***	0.01	0.23
Stability in problem behaviour over time												
Age 11 → Age 14	0.55***	0.01	0.50	0.60***	0.01	0.73	0.63***	0.01	0.64	0.58***	0.01	0.52
Cross-sectional relationships (covariances) between neighbourhood safety and problem behaviour												
Age 11	0.10***	0.01	0.08	0.05***	0.01	0.05	0.12***	0.02	0.02	0.10***	0.01	0.04
Age 14	0.04***	0.01	0.04	0.03***	0.01	0.05	0.02*	0.01	0.08	0.04***	0.01	0.10
Cross-lagged relationships between neighbourhood safety and problem behaviour												
NS _{age11} → PB _{age14}	0.14***	0.03	0.04	0.13***	0.03	0.03	0.09***	0.03	0.03	0.10***	0.02	0.04
PB _{age11} → NS _{age14}	0.01*	0.003	0.03	0.01**	0.003	0.03	0.01**	0.003	0.04	0.02***	0.004	0.04

* $p < .05$, ** $p < .01$, *** $p < .001$. β = standardised beta coefficient. PB = Problem behaviour, NS = Neighbourhood safety.

Table 4

Direct, indirect and total effects for models 2 and 3 (hypothesised models of mediation by personal victimisation and risky behaviour) for emotional symptoms.

	Direct		Indirect		Total	
	b (SE)	β	b (SE)	β	b (SE)	β
NS _{age11} → PV _{age14} → PB _{age14}	0.119(0.028)***	0.036	0.015(0.003)***	0.005	0.134(0.028)***	0.041
PB _{age11} → PV _{age14} → NS _{age14}	0.009(0.003)**	0.030	0.001(0.0003)**	0.004	0.010(0.003)**	0.034
NS _{age11} → RB _{age14} → PB _{age14}	0.129(0.028)***	0.184	0.001(0.001)	0.002	0.129(0.028)***	0.185
PB _{age11} → RB _{age14} → NS _{age14}	0.010(0.003)**	0.016	0.0001(0.0002)	0.001	0.010(0.003)**	0.016

Notes: $p < .05^*$, $p < .01^{**}$, $p < .001^{***}$. PB = Problem behaviour, NS = Neighbourhood safety, PV = Personal victimisation, RB = Risky behaviour.

Table 5

Direct, indirect and total effects for models 2 and 3 (hypothesised models of mediation by personal victimisation and risky behaviour) for conduct problems.

	Direct		Indirect		Total	
	b (SE)	β	b (SE)	β	b (SE)	β
NS _{age11} → PV _{age14} → PB _{age14}	0.064(0.020)**	0.026	0.011(0.002)***	0.004	0.075(0.020)***	0.031
PB _{age11} → PV _{age14} → NS _{age14}	0.008(0.004)	0.019	0.005(0.001)**	0.012	0.012(0.004)**	0.032
NS _{age11} → RB _{age14} → PB _{age14}	0.071(0.020)***	0.110	0.005(0.003)*	0.010	0.076(0.020)***	0.115
PB _{age11} → RB _{age14} → NS _{age14}	0.009(0.004)*	0.018	0.003(0.001)***	0.004	0.012(0.004)**	0.021

Notes: $p < .05^*$, $p < .01^{**}$, $p < .001^{***}$. PB = Problem behaviour, NS = Neighbourhood safety, PV = Personal victimisation, RB = Risky behaviour.

Table 6

Direct, indirect and total effects for models 2 and 3 (hypothesised models of mediation by personal victimisation and risky behaviour) for hyperactivity.

	Direct		Indirect		Total	
	b (SE)	β	b (SE)	β	b (SE)	β
NS _{age11} → PV _{age14} → PB _{age14}	0.074(0.028)**	0.129	0.012(0.003)***	0.017	0.085(0.028)**	0.140
PB _{age11} → PV _{age14} → NS _{age14}	0.006(0.003)*	0.011	0.002(0.0003)***	0.003	0.008(0.003)**	0.014
NS _{age11} → RB _{age14} → PB _{age14}	0.080(0.028)**	0.135	0.006(0.003)*	0.012	0.086(0.028)**	0.141
PB _{age11} → RB _{age14} → NS _{age14}	0.007(0.003)**	0.012	0.001(0.0003)***	0.002	0.008(0.003)**	0.013

Notes: $p < .05^*$, $p < .01^{**}$, $p < .001^{***}$. PB = Problem behaviour, NS = Neighbourhood safety, PV = Personal victimisation, RB = Risky behaviour.

Table 7

Direct, indirect and total effects for models 2 and 3 (hypothesised models of mediation by personal victimisation and risky behaviour) for peer problems.

	Direct		Indirect		Total	
	b (SE)	β	b (SE)	β	b (SE)	β
NS _{age11} → PV _{age14} → PB _{age14}	0.082(0.024)**	0.129	0.014(0.003)***	0.020	0.096(0.024)***	0.143
PB _{age11} → PV _{age14} → NS _{age14}	0.012(0.004)**	0.019	0.004(0.001)***	0.006	0.016(0.004)***	0.024
NS _{age11} → RB _{age14} → PB _{age14}	0.099(0.024)***	0.146	-0.002(0.001)*	-0.0002	0.097(0.024)***	0.144
PB _{age11} → RB _{age14} → NS _{age14}	0.016(0.004)***	0.024	0.0002(0.0002)	0.001	0.017(0.004)***	0.024

Notes: $p < .05^*$, $p < .01^{**}$, $p < .001^{***}$. PB = Problem behaviour, NS = Neighbourhood safety, PV = Personal victimisation, RB = Risky behaviour.

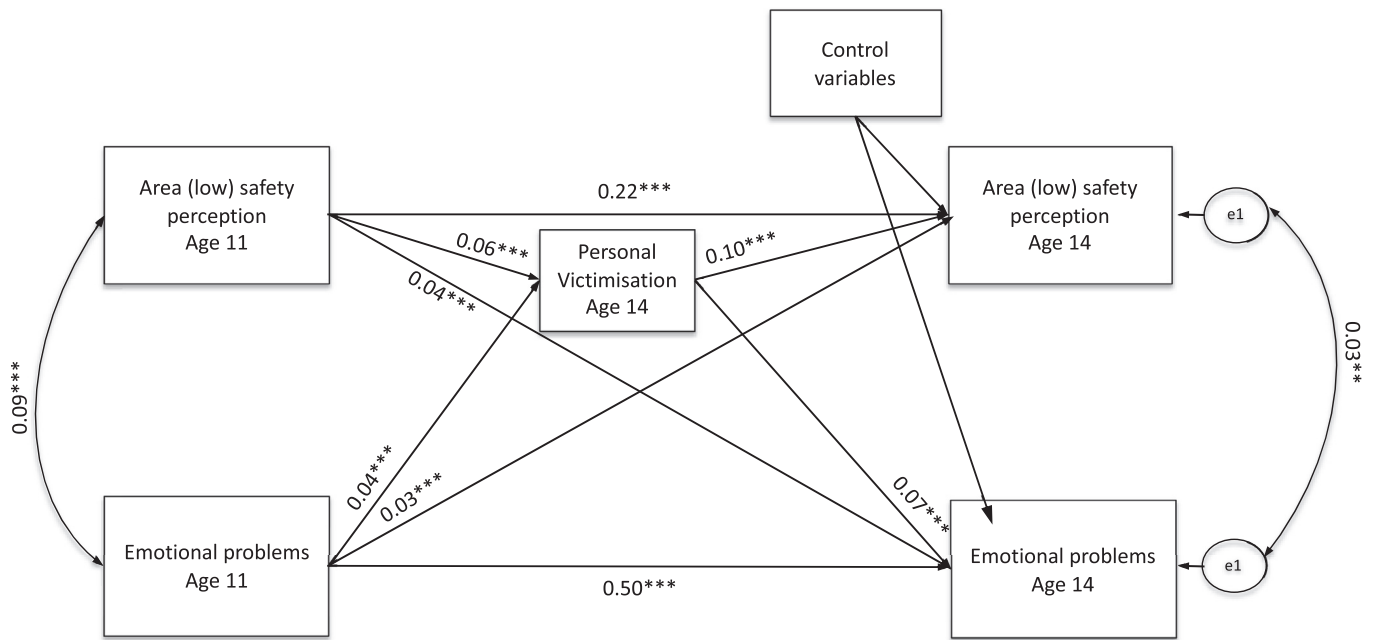


Fig. 2. Cross-lagged emotional symptoms model of neighbourhood safety and problem behaviour with personal victimisation as mediator. Notes. Coefficients are standardised. ** $p < .01$, *** $p < .001$. Control variables are family socio-economic disadvantage (at adolescent's age 11), maternal education by age 14, single parent status (age 11), maternal psychological distress (age 11), adolescent's age in months (age 14), gender, ethnicity (Mixed, Indian, Pakistani/Bangladeshi, Black or Other, compared to White) and MCS strata.

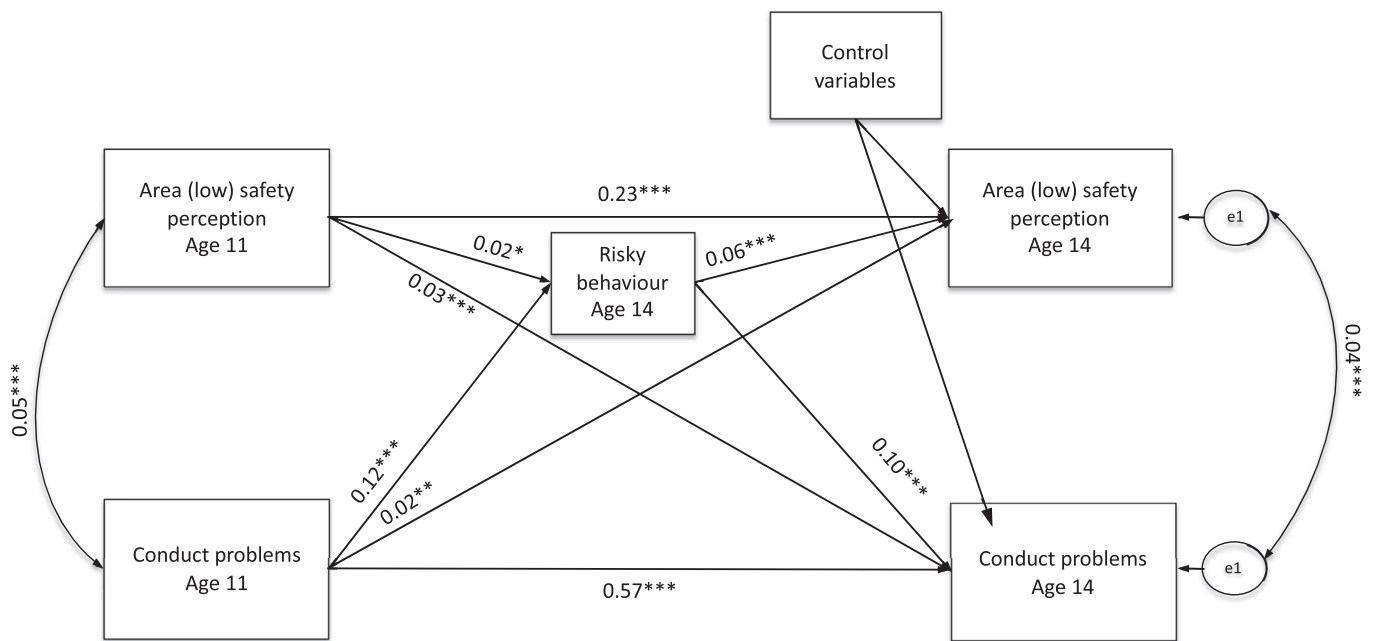


Fig. 3. Cross-lagged conduct problems model of neighbourhood safety and problem behaviour with risky behaviour as mediator. Notes. Coefficients are standardised. * $p < .05$, ** $p < .01$, *** $p < .001$. Control variables are family socio-economic disadvantage (at adolescent's age 11), maternal education by age 14, single parent status (age 11), maternal psychological distress (age 11), adolescent's age in months (age 14), gender, ethnicity (Mixed, Indian, Pakistani/Bangladeshi, Black or Other compared to White) and MCS strata.

all indirect effects remained in Models 2 and 3 (Tables S2-S5). Adding neighbourhood median income and residential mobility separately to the models shows that it was neighbourhood median income that was attenuating these direct cross-lagged effects.

Moreover, the size of the effects of neighbourhood safety perception and neighbourhood income was roughly equal (β s ranging 0.03-0.04) for emotional and conduct problems. Neighbourhood income did not

significantly predict hyperactivity at age 14 and its effect on peer problems at age 14 was larger than that of neighbourhood safety perception (neighbourhood income: $\beta = 0.06$, neighbourhood safety: $\beta = 0.03$).

Discussion

Although there is a fair amount of evidence that adolescents living in areas they view as unsafe are more at risk of emotional and

behavioural problems (Hill and Angel, 2005, Latkin and Curry, 2003, Ross and Mirowsky, 2001), our study is the first to explore the reciprocal relationships between adolescents' neighbourhood safety perceptions and their emotional and behavioural problems, allowing us to get closer to understanding the direction of these associations. We explored these while adjusting for a host of individual and family factors that may confound these relationships, as well as those that may be related to selective sorting of families into neighbourhoods. Ours is also the first general population study to assess why safety perceptions might predict problem behaviour and vice versa, by testing for mediation of these reciprocal relationships by personal victimisation and risky behaviour.

As expected, we found reciprocal associations between perceptions of safety and *all* domains of emotional and behavioural problems, such that adolescents in unsafe areas at age 11 had more problem behaviour at age 14, and problem behaviour at age 11 predicted a greater likelihood of perceiving one's area as unsafe at age 14. However, we found that, for emotional symptoms and conduct problems, the effect of area safety on problem behaviour was stronger than the effect of problem behaviour on area safety. Conversely, for hyperactivity and peer problems, the effect of problem behaviour was stronger than the effect of area safety. Although effects were small, as standardised coefficients for cross-lagged relationships ranged .02 to .10, they were robust to adjustments for stability paths and key child and parent/family covariates that may confound the associations.

Additionally, we were able to explain part of all significant reciprocal relationships with personal victimisation. The percent of total effect explained by personal victimisation ranged 10-42%. The more important (larger) effects of neighbourhood safety perceptions on emotional and conduct problems (rather than vice versa) were explained partly (11% for emotional symptoms and 10% for conduct problems). The small contribution of personal victimisation is not surprising. The victimisation experiences we considered can be very stressful and distressing, but (perhaps because of this) were also uncommon in our sample. In our study, the average adolescent reported experiencing less than one (.79) incident in the previous 12 months. However, even for those who are not victims, there remains the threat of victimisation, which can also be distressing because, as Ross and Mirowsky (2009; 2001) argue, it promotes alienated views. This 'ambient victimisation' (Ross and Mirowsky, 2009) may therefore also be important in explaining why unsafe neighbourhoods are harmful to mental health, but we were unable to capture this in our study. As for both peer problems and hyperactivity, 25% of the more important direction of the effect (from problem behaviour to neighbourhood safety) was accounted for by personal victimisation.

Why would certain types of problem behaviour play a more important role in one's perception of the neighbourhood than others? As previously mentioned, the direction of the association from peer and hyperactivity problems to neighbourhood safety was explained a fair amount by personal victimisation. Children demonstrating hyperactivity, which can be quite disruptive in a school or neighbourhood environment, as well as those experiencing relational issues with peers, may be more likely to be victimised or rejected by peers at school or in the neighbourhood (Matthews et al., 2015, Verlinden et al., 2015). As a result, they may dislike and feel unsafe at school and in their community. On the other hand, neighbourhood safety perceptions were more important for conduct problems and emotional symptoms in our study. Adolescents living in a dangerous area may experience social isolation due to anxiety and fear, in turn related to anger and depression (Ross and Mirowsky, 2009, Ross and Mirowsky, 2001) – symptoms and behaviours captured by the SDQ, our measure. Adolescents may respond to fear by either internalising their feelings resulting in emotional problems or by protecting themselves by behaving more aggressively, demonstrating conduct problems.

Risky behaviour, however, explained the links between neighbourhood safety and problem behaviour more weakly than did personal victimisation. Risky behaviour did mediate all reciprocal paths except for

three, but explained less of the total effect: it did not mediate the cross-lagged associations for emotional symptoms, or the link from peer problems to later neighbourhood safety, despite it being the path with the larger effect. The percent of total effect across the paths explained by risky behaviour ranged 1-25%. The more *important* effects from problem behaviour to perceptions of safety (rather than vice versa) for hyperactivity and peer problems were mediated very weakly by risky behaviour (12.5% for hyperactivity and 1% for peer problems).

Some of these weak mediation results notwithstanding, our cross-lagged effects remained despite additional adjustments for an objective neighbourhood measure – neighbourhood median income – as well as residential mobility. The effects of perceived neighbourhood safety and neighbourhood income were roughly equal in size (both small when considering the standardised coefficients) for emotional and conduct problems. Neighbourhood income did not predict hyperactivity and its effect on peer problems was larger than that of perceived neighbourhood safety. Little research has incorporated both objective and subjective measures of neighbourhood disorder, violence, safety or crime in the same study. What has been done suggests that perceptions are more important than objective indicators (Goldman-Mellor et al., 2016). Although neighbourhood income is distinct from neighbourhood crime or violence, typically viewed - when measured using administrative data on area crime - as objective indicators of area safety, our study shows that the relative importance of objective and subjective measures with regard to adolescent problem behaviour may depend on the behaviour domain considered.

Nonetheless, our study has a number of limitations. First, the families in our sample were more advantaged than those in the MCS who were not in the sample, and were more likely to report feeling safer in neighbourhoods (although reported experiencing more victimisation). Therefore, the results may not apply to a sample more diverse in terms of family and neighbourhood socio-economic characteristics. Second, the cross-lagged panel modelling that we adopted has some disadvantages despite its many strengths, including that it does not explicitly consider the passage of time, and that the window of time between waves may be too short, or too long, to capture the reciprocal effects. Third, our measure of neighbourhood safety is based on one item only that asked adolescents to report how safe the area around their home was to play in. Moreover, this measure does not specify the source of individuals' perceptions of safety (e.g., crime or traffic (Verlinden et al., 2015)). Ideally, we would have more items to tap into this construct to improve the quality of measurement, but we were limited by our data. Fourth, we could not consider important neighbourhood characteristics that may confound the associations we estimated. Reciprocal associations in fully adjusted models and mediation effects were robust to adjustments for neighbourhood income which relates to neighbourhood socio-economic disadvantage. Nevertheless, we did not have data on neighbourhood crime statistics or subjective indicators of disorder such as abandoned buildings or dog mess, which may be related to both neighbourhood safety and problem behaviour. Similarly, there may be unobserved family and adolescent characteristics that may be related to selection into neighbourhoods. Fifth, we only considered two mediators, both related, broadly, to crime. Other mediators theorised in the existing literature should be explored in future research, such as loneliness, stress and isolation (Ross and Mirowsky, 2009, Ross and Mirowsky, 2001). Relatedly, it may be interesting to assess biomarkers of stress and inflammation as there are some longitudinal, general population studies that provide these assessments. The data we used from the MCS unfortunately did not have measures of either. Sixth, self-reported measures like neighbourhood safety perception and problem behaviour are sensitive to common method bias, where personality or affective traits influence individuals' evaluations of their neighbourhoods and their risk of problem behaviour (Fujiwara and Kawachi, 2008, Meltzer et al., 2007). Last, our measure of problem behaviour had only adequate internal validity for conduct problems and peer problems (Cronbach's alphas ranging .60-.63).

Despite these limitations, our study has important strengths. Even after taking into account confounding and reverse causality in the association between neighbourhood safety perception and adolescent problem behaviour, our study documented reciprocal effects which also differed in both strength and direction according to problem behaviour domain. It also tested for explanations of these effects. Our findings suggest there is a dynamic and complex relationship between adolescents' perceived neighbourhood safety and their emotional and behavioural adjustment. Future research should explore these reciprocal relationships over a longer period across development, and should attempt to elucidate further the pathways linking them.

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.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.wss.2021.100036.

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