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Abstract

Objective: Negative home environments are associated with both schizophrenia-spectrum disorders and crime, but whether this is due to the social or cognitive sequelae of such environments is unclear. This study investigates the effect of early home environments on adult mental health. Method: Using data from the Mauritius Child Health Project, a multiple time-point prospective study where all children born in 1969 in two towns (Quatre Bornes and Vacaos) were recruited at age 3 years (N=1794), a group of children left home alone at age 3 (n=34) were compared to children cared for by siblings/relatives (n=222), or by mothers (n=1498) on antisocial behavior and schizotypal personality at ages 11, 17, and 23 years. Results: Home alone children showed higher scores on psychotic behavior and conduct disorder at age 17, and also schizotypal personality and crime at 23 years compared to the other groups. No negative behavioral or cognitive effects were observed at age 11. Findings were not accounted for by social adversity or ethnicity and appear to be 'sleeper effects' in that they do not emerge until later adolescence and into adulthood. Conclusions: Findings appear to be the first to show the negative effects of dual-parental daytime absence on adult schizotypy and crime, a finding that cannot be accounted for by verbal and spatial cognitive impairments. Results suggest an early common psychosocial denominator to the two comorbid conditions of antisocial behavior and schizotypy.

Keywords	Schizotypy, Parenting, Antisocial Behavior, Crime, Longitudinal, Development
Taxonomy	Etiology of Schizophrenia, Schizotypal Disorders, Conduct Disorder, Antisocial Personality Disorder
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Submission Files Included in this PDF

File Name [File Type]

JPR_HomeAlone_Title_260818.docx [Cover Letter]

JPR_Home_Alone_Revisions_260818_submit.docx [Response to Reviewers]

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Research Data Related to this Submission

There are no linked research data sets for this submission. The following reason is given:
Data will be made available on request

The effect of being left home alone at age 3 years on schizotypy and antisocial behavior at ages 17 and 23 years.

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Abbreviated title: Prospective longitudinal study of being left home alone on schizotypy and crime.

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Conflict of interest: None.

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Dr. Florian Holsboer
Editor-in-Chief
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26 August 2018

Dear Dr. Holsboer,

RE: Being left home alone at age three years is associated with increased schizotypy and antisocial behavior at ages 17 and 23 years (JPSYCHIATRRES_2018_614)

Thank you for allowing us to revise our manuscript and for the two very helpful sets of reviews. We appreciate the opportunity to address their concerns and resubmit our manuscript. Enclosed please find our revised manuscript that we would like to be considered for publication in the *Journal Psychiatry Research*. All in-text revisions are in red and we explain how we addressed each of the reviewer's comments below. We would also like to raise the point that our co- author, Professor Peter Venables has passed away since our completion of this paper. Peter contributed greatly to this paper and had set-up the Mauritius study, and I (Adrian Raine) can honestly say that he had a very particular interest in these findings. Thus our first choice is to retain Peter as a co-author on this paper. We hope that this would be acceptable to you. Please let us know if this is not your journal's policy, and we would alternatively acknowledge his contribution under acknowledgements and dedicate the paper to him.

We have made a concerted effort to respond to each and every point made by the reviewers, and these responses are as follows:

Reviewer 1
1. It would be interesting to report statistics regarding the rates of crime and schizophrenia-spectrum disorders in the general population or Mauritius to see if the numbers reported in this study are reflective of the overall diagnosis patterns in Mauritius. Do these results generally line up with rates seen here in the United States? Thank you for your suggestion. There are unfortunately no base rates of schizotypy in Mauritius. We have however made comparisons on schizotypy and crime rates between Mauritius and the US in the Method section of the manuscript (p.5). Mauritius and the U.S. are comparable on schizotypy, although crime rates are somewhat lower.

2. Are there any behavioral data available for age 3 (e.g., CBCL 1 ½-5)? Authors controlled for social adversity, malnutrition, and IQ at age 3, but wouldn't it also be important to examine behavioral features (i.e., impulsivity, social withdrawal, poor emotion regulation etc.) as possible confounding variables? Thank you for your suggestions. Yes, we do have behavioral data for age 3 including the extent to which children at age 3 were fearful or stimulation seeking rated by the research assistant during psychophysiology testing as detailed in a previous paper (Raine et al., 1998).

   Taking the reviewer's advice, we tested and found that Home Care status was not correlated with simulation seeking (p = .38) and fearlessness (p = .44). A multivariate analysis controlling for ethnicity, social adversity, stimulation seeking and fearlessness also did not change the observed and reported relationships between Home Care status and outcome variables at 11, 17, and 23 years; thus indicating that

age 3 stimulation seeking and fearlessness were not confounding variables. These results are now included in the revised manuscript in p.5, p.8, p.11 and Table 2.

Age 3 Home Care status continued to be related to outcome variables at age 17 and 23 even after controlling for relevant age 11 behaviors, background variables and fearlessness and stimulation seeking (Age 17: CD [p =.012], PB [p = .009]; Age 23: SPQ total [p=.043], Disorganized [p = .004], Self-report Crime [p = .021]).

3. What was done to ascertain that the assessments used were culture-fair? How were the measures translated, and were they back-translated? If this is already explicitly detailed in another paper published from this dataset, it should be so stated, and that paper should be cited.
Even though English is the official language in Mauritius, a majority of the sample speak Creole (80.5%), which is based largely on French with English, Hindi, Malay, and Chinese contributions. All measures used and interviews were conducted in Creole (Raine, Liu, Venables, Mednick, & Dalais, 2010). Measures used in this study were translated and back-translated as detailed in previous papers (Gao et al., 2009; Raine et al., 1998; Venables, 1994; Venables, 1996; Venables, 1989). All of these papers have now been cited in the revised manuscript (p. 4-5).

4. Is there a way for the authors to further study sibling care vs. relative care? Perhaps I am misunderstanding the construct in this sample, but I imagine that there is a lot of variability in the ages of the siblings providing care and this could possibly lead to different behavioral outcomes. While I would still expect the home alone group to have the highest rates of behavioral problems, there might be variability in the sibling/relative group.
Thank you for this very interesting suggestion. Although we do not have specific information on the age of the siblings, we do know that they were all older than the target sample children. Following the reviewer's advice, we reran our multivariate analyses with Bonferroni post-hoc contrasts on the same outcome variables at 3, 11, 17, and 23 years using a four-group construct (sibling care [n=63], relative care [n=159], mother care [n=1498], and home alone [n=34)]). We compared the findings to the original results in eTable 2. As there are quite a lot of analyses, we have now referred to these findings on p. 10-12 and tabulated them in the supplementary materials, as eTable4.

Overall multivariate analyses with Bonferroni post-hoc multiple comparisons across the four groups for observed means did not change the main effects of Home Care status and outcome variables observed at 3, 11, 17, and 23 years. As expected by the reviewer, the Home Alone group scored significantly higher than the other groups on all of the outcome measures. The order of relationship tended to descend in order of severity from Home Alone followed by the Sibling-care, Relative-care and Mother-care groups.

Overall, children in the Sibling-care group scored significantly higher on social adversity and significantly lower on age 11 schizoid personality traits compared with the Relative-care group (a new finding included on p.8). At age 17, Home Alone children reported significantly more psychotic behaviors than children in the Mother-care, Relative-care and Sibling-care groups. At age 23, the Home Alone group reported significantly more crimes than Mother-care and Sibling-care groups and more

schizotypal disorganized traits than the Mother-care group. All effects were sustained even after controlling for social adversity and ethnicity. These results were included in the respective parts of the Results sections as detailed below.

Age 3
There was no gender difference across all four groups. In terms of ethnicity, there were significantly more Hindu/Tamil/Muslim/Creole children in the Mother-care group than there were in the Relative-care group (p = .007, d = .276). In terms of levels of social adversity, the Sibling-care group had on average the highest social adversity score ($M = 3.37$, $SD = 1.37$) and that this was significantly higher than those cared for by their mothers (p < .000, d = 1.166) and relatives (p <.000, d = .946), but not significantly different from the Home Alone group (p = .064).

Age 11
There were no group differences across all age 11 behavioral and cognitive measures apart from schizoid personalities traits. The Relative-care group scored significantly more schizoid personality traits than children cared for by their mothers (p = .049, d = .230) and siblings (p = .030, d = .465). These findings were still significant even after controlling for social adversity and ethnicity. These findings have now been included in the revised manuscript (p.11).

Age 17
The overall effects at age 17 remained the same for both conduct disorder, psychotic behaviors and schizotypy. Home alone children scored significantly higher for conduct disorder symptoms compared with Mother-care children (p = .004, d = .436) and Relative-care (p = .008, d = .435) groups and significantly higher psychotic behaviors than children in the Mother-care (p = .004, d= .388), Relative-care (p = .019, d =.371) and Sibling-care (p = .029, d=.393) groups. These findings were still significant even after controlling for social adversity and ethnicity. Findings have now been included in the revised manuscript (p.11).

Age 23
The overall main effects for self-reported crime and schizotypy were unchanged with the new grouping. Individuals in the Home Alone group self-reported significant more crimes than the Mother-care (p = .020, d = .373) and Sibling-care groups (p = .030, d = .465). Home Alone children also reported significantly more schizotypal traits, namely Disorganized traits, compared to individuals in the Mother-care group p = .007, d = .519). These findings remained significant even after controlling for social adversity and ethnicity. These findings have been included in the revised manuscript (p.11).

5. In the first paragraph of the discussion section (page 10), the authors state that "early parental abandonment" predisposes to schizotypy, CD, and crime. I am not sure this is the best word choice here. The parents are not abandoning their children, but are leaving them home along while they work. In fact, the authors go on later in the discussion section to state that the children in "home alone" group are not neglected. This word choice discrepancy should be corrected.
Thank you for the suggestion. This has now been revised to: "To our knowledge, this is the first naturalistic study to show that the effects of parents leaving children home

alone predispose to schizotypy, conduct disorder, and crime independent of cognitive and nutritional influences."

6. Did the authors test for other possible precursors to behavioral problems? For example, is it possible that youth at age 11 are not yet displaying externalizing behavioral problems, but have poor social skills, limited interactions with peers, are rejected by peers, etc.? If they spent less time interacting with others, this might first manifest in social rejection during school age, which then translates into deviant behavior in adolescence.

Yes, we agree that this could be the case. We do not however have data on school peer rejection and measures of social skills at age 11 aside from the CBCL items. According to Achenbach's latest paper on the CBCL norms (Achenbach et al., 2017), the average Total Problem Score across 42 societies (N = 69, 866) ranges from 14 to 42, with a mean of 24.04 (SD = 6.74), which is comparable to our sample mean of 25.84 (SD = 12.86). Each subscale has a good range of scores and variance, although like most studies, both internalizing and externalizing problem behaviors were positive skewed with the majority of children scoring low.

Citation: Achenbach, T. M., Ivanova, M. Y., & Rescorla, L. A. (2017). Empirically based assessment and taxonomy of psychopathology for ages 1½–90+ years: developmental, multi-informant, and multicultural findings. *Comprehensive psychiatry*.

7. Related to the point above, the authors focus almost exclusively on PFC development in adolescence as one possible mechanism by which being home alone relates to later behavioral problems. There is ample literature that also correlates early life stress to amygdala functioning across development. Furthermore, as I mentioned above, it could be that home alone children have poorer social skills and fare worse in social settings, thereby being at greater risk for peer rejection. The authors should expand their discussion beyond potential brain (PFC) correlates of the link between being left home alone and schizotypy/antisocial behavior.
Thank you for your suggestion. We have now included a discussion of early life stress (ELS) to amygdala functioning in children and included the suggestion that ELS may result in poor skills and peer rejection, which in turn may be associated with antisocial behaviors (see p. 15).

8. Can the researchers test abuse (verbal, physical, sexual) as a potential covariate? Families with greater adversity may have higher levels of abuse in the home, which could be related to EB problems in youth.
This is an interesting suggestion, but unfortunately, we do not have any measures of child abuse in this sample.

Thank you again for your very helpful comments and your positive reaction to the manuscript.

Reviewer 2

The manuscript reports results from a study examining long term effects of a specific form of neglect (being left home alone during the day early in life) on psychotic behavior, schizotypy, conduct disorder and antisocial behavior in adolescence / young adulthood. This study can be seen in parallel with other studies examining the effects of early deprivation on later mental problems and disorders, for example the Romanian adoptees study. It sheds more light to "sleeper effects", i.e., delayed effects on the incidence of schizophrenia spectrum disorders and antisocial behavior. Intriguingly, these effects could be shown at age 17 and 23, but not at age 11. A better understanding of delayed effects in the etiopathogenesis of these disorders is one of the keys for further research progress. It would be interesting to extend the discussion on this.

Thank you. We have now introduced the parallel English and Romanian Adoptees study (p.1) and discussed the findings of the study on p.14-15.

The study is technically sound and the manuscript is well written. However, Table 2 is mentioned in the text (p. 7, p. 9) but was not included in the pdf-document. Thus, it was not possible to keep track of the whole analysis.

Thank you for spotting this. We have now uploaded Table 2 as well, apologies.

Minor issues:

- In the "Statistical procedures" section, the models used in bivariate analysis (Table 1) were mentioned but not the models used in multivariate analysis (Table 2, not included).

Thank you for catching this. We have now corrected this and added the models used in Table 2.

- Typo: "varies", see p.9, last para

We have now corrected this and changed the word to 'various'.

We hope you agree that these results are likely to interest a wide readership within the *Journal of Psychiatry Research* and we look forward to receiving reviewers' comments in the near future.

Yours sincerely,

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Abstract

Objective: Negative home environments are associated with both schizophrenia-spectrum disorders and crime, but whether this is due to the social or cognitive sequelae of such environments is unclear. This study investigates the effect of early home environments on adult mental health. **Method.** Using data from the Mauritius Child Health Project, a multiple time-point prospective study where all children born in 1969 in two towns (Quatre Bornes and Vacaos) were recruited at age 3 years (N=1794), a group of children left home alone at age 3 (n=34) were compared to children cared for by siblings/relatives (n=222), or by mothers (n=1498) on antisocial behavior and schizotypal personality at ages 11, 17, and 23 years. **Results.** Home alone children showed higher scores on psychotic behavior and conduct disorder at age 17, and also schizotypal personality and crime at 23 years compared to the other groups. No negative behavioral or cognitive effects were observed at age 11. Findings were not accounted for by social adversity or ethnicity and appear to be 'sleeper effects' in that they do not emerge until later adolescence and into adulthood. **Conclusions.** Findings appear to be the first to show the negative effects of dual-parental daytime absence on adult schizotypy and crime, a finding that cannot be accounted for by verbal and spatial cognitive impairments. Results suggest an early common psychosocial denominator to the two comorbid conditions of antisocial behavior and schizotypy.

Keywords: Antisocial Behavior, Schizotypy, Parenting, Longitudinal, Development

Introduction

Schizophrenia has often been thought to be a risk-factor for violence and criminal behavior, with patients being on average 7 times more likely to commit homicide than controls (Eronen et al., 1996). Conversely, incarcerated homicide offenders have also been found to have higher rates of schizophrenia than offenders of other crimes (Arseneault et al., 2003; Fazel et al. 2009a), with a large meta-analytic review of 9 international studies suggesting an overall large effect between schizophrenia and violence, $d = .81$ (Brennan & Alden, 2006). Patients with psychosis have 20% to 33% chance of being victims of violent crime compared to the general population (de Vries et al., 2018). Although the relationship between schizophrenia and crime is well established over the last three decades (Raine, 2006), what is less researched are the factors common to *both* schizophrenia and crime, which are necessary to help us understand the etiology of these disabling conditions. Structural abnormalities in the prefrontal cortex, temporal cortex, and the amygdala-hippocampal complex have been hypothesized to be related to criminals and patients with schizophrenia (Cannon & Raine, 2006); and relatedly, in community adults with antisocial behavior and schizotypy (Lam et al., 2015). Comorbid substance abuse characterizes violence in patients with schizophrenia (Brennan & Alden, 2006; Fazel et al. 2009b) and schizophrenia-spectrum disorders such as schizotypal personality disorder (Toftdahl, Nordentoft, & Hjorthøj, 2016). Furthermore, cognitive impairments in executive functioning have been found to predispose to later crime, schizophrenia (Brower & Price, 2001; Minzenberg et al. 2009), and schizotypal personality disorder (Seeber & Cadenhead, 2005; Trotman, McMillan, & Walker, 2006).

One plausible etiological process common to both schizophrenia-spectrum disorders including schizotypal personality and antisocial criminal behavior is a negative home environment. This is consistent with studies on the effects of early childhood institutional deprivation on later mental health problems, such as the English and Romanian Adoptees

study (Rutter, 1998). A comprehensive review of more than 130 studies on early childhood trauma and adult psychosis demonstrated a dose-response relationship, whereby increased abuse predicts an increase in psychotic symptoms (Read et al. 2005). Population-based studies sampling individuals yet to have contact with mental health services also support a possible causal link between childhood trauma and later psychotic symptoms (Kelleher et al. 2008), and considerable evidence for childhood maltreatment predisposing to later antisocial behavior has also been reported (Caspi et al. 2002). Notably, poor parental supervision is one of the strongest predictors of later conduct disorder and crime (Farrington, 2010). Disruption to the parent-child relationship may therefore be an early developmental risk-factor for both schizophrenia-spectrum disorders and crime.

An important methodological issue in arguing that disruption to the child-parent relationship results in later psychopathology is that early social adversity (e.g., living in poor housing, uneducated parents, parental mental illness, overcrowded house, no electricity) has been consistently associated with poor cognitive functioning (Hackman, Farah, & Meaney, 2010). Consequently, the relationship between parent-child attachment and both crime and schizotypal personality may be a confound of cognitive dysfunction. Similarly, social deprivation is also associated with poor nutrition, which in turn is associated with both antisocial behavior and schizotypal personality (Neugebauer, Hoek, & Susser, 1999; Venables & Raine, 2012). This is a particularly difficult methodological issue to overcome given that social relations cannot be experimentally manipulated independent of the cognitive and nutritional sequelae of early deprivation, but maybe observed in a prospective cohort study like this one.

This study reports on the effects of being left home alone early in life on the individual's antisocial and psychotic behaviors in late adolescence and adulthood using a prospective cohort longitudinal study, the Mauritius Child Health Project (N=1794). We

capitalize on the unique multiple time-point design of the project. First, home alone children were compared to children cared for by their siblings/relatives and those cared for by their mothers on cognitive functioning at 3 and 11 years. Second, groups were compared on measures of antisocial and schizotypal personality at 11, 17, and 23 years. Third, to test whether relationships were specific to externalizing behaviors, groups were compared on measures of anxiety, withdrawal, depression (internalizing behavior) and alcohol use. Fourth, we controlled for ethnicity and social adversity, an index composed of 14 indicators, to examine whether group differences on antisocial behavior and schizotypal traits were sustained.

Method

Participants

Participants were drawn from the Mauritius Child Health Project cohort of 1794 children, of which 51.8% were male (Raine et al. 2010). Children born in 1969 in two towns (Quatre Bornes and Vacaos) were recruited at age 3 years. The ethnic makeup of this self-identified birth cohort was: 68.3% Indian (Hindu, Tamil, Muslim), 25.7% Creole, 1.8% Chinese, and 3.8% other (English or French decent). Females made up 48.2% of the sample. Parental verbal informed consent was initially obtained and in later waves of the study, directly from the subjects themselves. The work was carried out in accordance with the the ethical standards of the Declaration of Helsinki (1964) for the early phases and the revised version in 2008, the relevant national and institutional committees on human experimentation, and in accordance with the Belmont Report (1979) in later phases.

Home care status at age 3 years

The child's guardianship was first assessed by a social worker who visited the home when the child was aged 3. Based on this assessment, an invitation was extended to the mothers or carers to attend a subsequent interview in the laboratory, where the adult who brought the child into the laboratory was reassessed. They were asked, "Do you work?" Where the answer was 'no' this was followed by the question, "Do you look after the child then?" If they said they worked, they were asked, "Who looks after the child when you are at work?" Responses were coded to create a care grouping as follows: cared for by their mother (*n*=1498, male = 52.3%), cared for by siblings/relatives (*n*=222, male = 48.2%), or left home alone (*n*=34, male = 64.7%) in cases where both the social worker's and researcher's observations converged to 'no guardian present'. Primary analyses were conducted on this 3-grouping construct, with exploratory analyses based on 4 groups to further examine group differences between Sibling-care and Relative-care (i.e., sibling-care [n=63], relative-care [n=159], mother-care [n=1498], and home alone [n=34)]).

Outcome Measures at 11, 17, and 23 Years

Data available for each variable by home care membership is reported in eTable 1 online.

Schizotypy and antisocial behavior at age 11 years. Parents rated their child's behavior on the Child Behavior Checklist (CBCL) (Achenbach et al. 1987). Six subscales assessing aggression, delinquency, schizoid traits, anxiety, depression, and withdrawal were used. All measures were translated and back-translated and checked for accuracy. Full details of translation, reliability and validity are provided elsewhere (Raine et al. 1998). Data were available on 1176 individuals.

Schizotypy, Psychotic Behavior, and Conduct Disorder at Age 17. The Schedule for Attitudes and Experiences (SAE) is a self-report schizotypy measure with subscales

measuring cognitive-perceptual, interpersonal deficits, and disorganized features (Venables, 1989; Venables, 1996; Venables & Raine, 2015). Data were available on 771 individuals.

The Revised Behavior Problem Checklist (RBPC) was completed by parents, teachers/employers and assesses six subscales: conduct disorder, psychotic behavior, socialized aggression, attention problems, and anxiety-withdrawal, and motor excess (Quay & Peterson, 1987). Data were available on 608 individuals.

Schizotypy, Crime, Depression, and Alcohol Use at 23 Years. The Schizotypal Personality Questionnaire (SPQ) is a widely used standard self-report measure of cognitive-perceptual, interpersonal, and disorganized features of schizotypy with excellent reliability and validity (Raine, 1991). Data were complete on 1201 individuals. Scores on schizotypal personality are comparable in Mauritius to those in the U.S. The top 10% of the Mauritius sample scored 42 points or above on the SPQ, consistent with previous studies of U.S. populations finding that the top 10% of the sample scored 41 points or above (Raine, 1991; Raine, 2006).

Self-report crime was measured using a structured interview assessing 41 criminal offenses over the last five years (e.g., theft, driving and traffic offences, drug crime, alcohol and property related). Scale reliability (α) was .84. Full details are provided elsewhere (Gao et al., 2009; Raine et al. 2003). Data were available on 1253 individuals. In Mauritius, 32.1% self-reported one or more crimes at age 23 years while 5.2% had one or more official crime records, a level somewhat lower than U.S. rates (52.8% and 6.2% respectively (Gilman et al., 2014).

Alcohol use was assessed using the Michigan Alcohol and Substance Use Test (MAST) Participants reported separately on alcohol usage of their father, mother, and themselves. Reliability and validity data are provided elsewhere (Selzer, 1971). Data were complete on 1112 individuals.

Depression was assessed using the 21-item self-report Beck Depression Inventory (BDI) (Beck et al. 1961). Data were available on 1268 individuals.

Potential Confounds.

Behavioral measures at 3. Age 3 behavioral measures of children's fearlessness and stimulation seeking as assessed by a research assistant during psychophysiological testing have been documented in detail elsewhere (Raine et al., 1998). As aggressive versus non-aggressive children in this sample were found to be more fearless and stimulation seeking, we controlled for these as potential confounds. Complete data were available on 1789 children.

IQ at 3 and 11 years. Age 3 measures of verbal and performance cognitive ability were derived from subtests of the Boehm Test of Basic Concepts–Preschool Version, designed to assess the fundamental verbal and spatial concepts (Boehm, 1986). Age 11 estimated child verbal and performance IQ were assessed using seven subtests of the Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1967). Full details of test construction, reliability, and validity are provided elsewhere (Raine et al. 2002). Complete data were available on 1388 individuals for verbal and 1453 individuals for performance IQ at age 3 and 1260 individuals for verbal and performance IQ at age 11.

Malnutrition at age 3. Seven indicators of malnutrition were assessed in a pediatric examination of the child at age 3 years conducted by pediatricians. A confirmatory factor analysis established a one-factor (malnutrition) model, with high scores on the factor indicating more malnutrition (Raine et al. 2003).

Social Adversity at Ages 3 and 11 years. A social adversity index (SAI) was constructed based on 14 variables collected by home-visiting social workers at ages 3 and 11 (see eTable 2). This index was created by adding 1 point for 14 different indicators of adversity (e.g. low SES, large family size, living in poor housing, uneducated parents, no

water or electricity) (Raine et al. 2002). Complete data were available on 1794 individuals at age 3 and 1272 at age 11.

Statistical Procedures

  The three groups were first compared on potential confounds and relationships with other study variables using, Pearson's, Spearman's and Kendall's tau-b (Table 1). Phi and Cramer's V test were used to test for group differences in gender and ethnicity. Univariate analysis (for single measure of the constructs) and multivariate analysis (for composite total and subscale scores) were conducted with group membership (mother care, sibling/relative care, home alone) as the independent variable predicting behavioral outcomes at later ages using SPSS 22.0 (Table 2). Bonferroni corrections were applied to significant between-group contrasts to protect against Type I error. Effect sizes were calculated using partial eta squared (η^2) and Cohen's *d* (1988) with indications of effect size (.20 (small), .50 (medium), and large (.80+). Specific to this study, missing imputation using expectation-maximization (EM) was conducted for age 17 and age 23 data to ascertain that the key study relationships observed were not spurious due to missingness. Although there was attrition at different phases of the study, previous studies have shown that those tested do not differ to those not tested on basic demographic variables (Raine et al. 2010; Reynolds et al. 2000).

  As more data were missing at age 17 than at other phases in this study, we conducted Little's (1988) MCAR test to assess whether the data were missing completely at random (MCAR), where a non-significant test warrants the use of missing data imputation using expectation-maximization (EM). For all age 17 and 23 variables, Little's MCAR was not significant (age 17: $\chi^2(df)=327.376(295)$, *p*=.09; age 23: $\chi^2(df)=35.01(30)$, *p*=.24) and therefore EM was conducted. To ascertain that our findings were not spurious due to

missingness, findings of all pre- and post-imputation analyses for all ages were compared to confirm results (see eTable3 Online).

Results

Assessment of potential confounds.

There was no main effect of gender on the Home Care group ($Phi=.05$, $V=.05$, $p=.17$). In contrast, there was a main effect of ethnicity on Home Care grouping ($Phi=.16$, $V=.11$, $ps<.001$), with a larger proportion of Indians (71.70%) in the mother-care group compared to the sibling/relative-care (56.35%) and home alone (52.90%) groups. There was an overall main effect of Home Care on social adversity at age 3, $F(2,1754)=26.68$ ($p<.001$) and at age 11, $F(2,1245)=4.17$ ($p<.05$). Children cared for by siblings, relatives and children left home alone both scored significantly higher on social adversity than children cared for by mothers at age 3 (Table 1 & 2). Findings at age 11 mirrored those at age 3 with both children cared for by siblings and also children left home alone scoring significantly higher on social adversity than children cared for by mothers (Table 1 & 2). Thus, we controlled for social adversity and ethnicity in our analyses.

Attrition analyses at age 17.

Due to attrition at age 17, attrition analyses were conducted and revealed that participants and non-participants did not differ on social adversity ($p=.28$), gender ($p=.29$), ethnicity ($p=.06$), and Home Care status ($p=.69$). Findings from all analyses conducted on pre- and post-imputed data were replicated suggesting that missingness did not confound the relationships observed at various ages (see eTable 3 online).

Behavioral, Cognitive and Nutritional Parity at Ages 3 and 11 Years.

MANCOVAs demonstrated that the three groups did not differ on behavioral assessments and IQ at ages 3 and 11 and showed parity on nutritional status at age 3 (Table 2).

Schizotypy and antisocial behavior at ages 11, 17, and 23.

Age 11. MANCOVAs showed that groups did not differ on any behavioral problems at age 11, Pillai's Trace=.01, Wilks' Lambda=.99, p=.84 (Table 2).

Age 17. MANCOVAs demonstrated that groups did not differ on self-report schizotypy, consisting of SAE total schizotypy, cognitive-perceptual distortions, disorganization, and interpersonal, Pillai's Trace=.02, Wilks' Lambda=.97, p=.15 (Table 2). Although when values were imputed, children left home alone reported significantly more schizotypal traits (d = .488), particularly cognitive-perceptual (d = .522) and disorganized features (d = .516) compared to children in the mother-care group (eTable3).

Home Care groups differed on conduct problems (F[2,1802]=5.85, R^2_{adj}=.02, p<.01) and psychotic behaviors (F[2,1802]=5.75, R^2_{adj}=.03 , p<.01) (Table 2, Figure 1). Further post-hoc Bonferroni corrections detailed in eTable3 indicated that home alone children exhibited significantly more conduct problems (M=10.27, SD=7.73, d_{range} = .399 to .420) and psychotic behaviors (M=2.04, SD=2.14, d_{range} = .376 to .388) compared to all groups, while mother-care and sibling/relative care groups did not differ on conduct problems ($M_{mother-care}$=7.64, SD=4.32; $M_{sibling-care}$=7.78, SD=4.25) and psychotic behaviors ($M_{mother-care}$=1.38, SD=1.10; $M_{sibling-care}$=1.40, SD=1.10). Groups did not differ on socialized-aggression (p=.09), attention problem (p=.11), anxious withdrawal (p=.46), and motor excess (p=.18). All main effects remained significant even after controlling for social adversity and ethnicity (ps<.001).

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Age 23. Home alone group (M=32.14, SD=13.67) had significantly higher total schizotypy scores compared to mother-care (M=23.77, SD=12.91) and sibling-care (M=25.79, SD=14.60) groups (ps<.01), even after controlling for ethnicity and socioeconomic status (Table 2, Figure 2). Compared to the mother-care and sibling-care groups, the home alone group reported significantly more schizotypal traits for disorganization (p<.001), and cognitive-perceptual deficits (p<.05), but not for interpersonal deficits (p=.20) (Table 2). The main effect of Home Care grouping on disorganization remained significant (F[2,1174]=7.17, R^2_{adj}=.03, p<.001) and was led by the home alone and mother-care group contrasts, $p < .007, d = .518$ (eTable3). Effects remained even with cognitive-perceptual, interpersonal features, ethnicity and socioeconomic status as covariates (p<.01), indicating relative specificity of home care effects on disorganization.

Home alone children self-reported significantly more criminal offenses compared to both the mother-care children (Bonferroni correction = F[2,1225]=4.73, R^2_{adj}=.01, p<.01, $d = .373$) and sibling-care group ($p = .03, d = .367$) (Table 2, Figure 3). These effects remained even after controlling for ethnicity and socioeconomic status (Table 2).

Depression & Alcohol at age 23.

ANCOVAs demonstrated that groups did not differ on depression (p=.52) or alcohol use for themselves (p=.54), their fathers (p=.32), and mothers (p=.26).

Controlling for social adversity and ethnicity.

All prior relationships remained significant controlling for social adversity at age 3 and 11 and ethnicity of individuals (ps<.05).

Four-group analyses separating Sibling-care and Relative-care.

The above analyses were repeated using a four-group construct (sibling-care [n=63], relative-care [n=159], mother-care [n=1497], and home alone [n=34)]) to further explore differential effects for Sibling-care versus Relative-care groups. Overall multivariate analyses with Bonferroni post-hoc multiple comparisons across the four groups for observed means did not change the main effects of Home Care status and outcome variables observed at 3, 11, 17, and 23 years (see supplementary materials eTable4). The Home Alone group still scored significantly higher than the other groups on all of the outcome measures, with a descending order of severity from Home Alone followed by the Sibling-care, Relative-care and Mother-care groups.

Age 3. There was no gender difference across all four groups. In terms of ethnicity, there were significantly more children who were of Hindu/Tamil/Muslim origin in the Mother-care group than there were in the Relative-care group ($p = .007$, $d = .276$). In terms of levels of social adversity, the Sibling-care group had on average the highest social adversity score ($M = 3.37$, $SD = 1.37$) and this was significantly higher than those cared for by their mothers ($p < .000$, d $= 1.166$) and relatives ($p < .000$, $d = .946$), but not significantly different from the Home Alone group ($p = .064$).

Age 11. There were no group differences across all age 11 behavioral and cognitive measures apart from schizoid personality traits. The Relative-care group had higher schizoid personality traits than children cared for by their mothers ($p = .049$, $d = .230$) and siblings ($p = .030$, $d = .465$). These findings remained significant after controlling for social adversity and ethnicity.

Age 17. Overall effects at age 17 remained the same for both conduct disorder, psychotic behaviors and schizotypy. Home alone children scored significantly higher on conduct disorder symptoms compared with Mother-care children ($p = .004$, $d = .436$) and Relative-care ($p = .008$, $d = .435$) groups and also scored significantly higher on psychotic

behaviors than children in the Mother-care (p = .004, d = .388), Relative-care (p = .019, d =.371) and Sibling-care (p = .029, d =.393) groups. These findings remained significant after controlling for social adversity and ethnicity.

Age 23. The overall main effects for self-reported crime and schizotypy were unchanged with the new grouping. Individuals in the Home Alone group self-reported more crimes than the Mother-care (p = .020, d = .373) and Sibling-care groups (p = .030, d = .465). Home Alone children also reported significantly more schizotypal traits, namely Disorganized traits, compared to individuals in the Mother-care group p = .007, d = .519). These findings remained significant even after controlling for social adversity and ethnicity.

Expectation-maximization (EM) imputation.

To eliminate the notion that our results are spurious due to missingness at varies phases of follow-up (i.e., Type I error), we compared the findings pre- and post-EM imputation at ages 11, 17, and 23 years to determine whether the observed relationships would be retained. Post imputation analyses demonstrated that compared with the sibling-care and mother-care groups, children left home alone at age 3 still showed significantly more psychotic behavior and conduct disorder at age 17 years (d=.04 to .42), significantly more crime and schizotypal personality at age 23 (d=.33 to .66) with small to medium effect sizes.

Discussion

The main finding of this study is that children left home alone at age 3 show more psychotic behavior and conduct disorder at age 17 years, and more crime and schizotypal personality at age 23 years compared to groups cared for by either siblings/relatives or mothers (controls). Effect sizes ranged from large, d=.77 to .86 at age 17 to medium d=.39 to

.76 at age 23 with pre- and post-imputation producing identical results, albeit more conservative effect sizes (age 17: d=.04 to .42; age 23: d=.33 to .52). This effect could not be attributed to the behavioral, cognitive or nutritional sequelae of early social isolation. Furthermore, broader aspects of social adversity, which includes whether parents are psychiatrically ill, could not account for these findings (see online eTable2). The developmental effects of being left home alone were relatively specific to externalizing behavior and schizotypy, and do not extend to anxiety, withdrawal, depression, and alcohol use. To our knowledge, this is the first naturalistic study to show that the effects of parents leaving children home alone predispose to schizotypy, conduct disorder, and crime.

Specificity, Sleeper Effects, and Cognitive-Nutritional Parity

The effect of being left home alone on later psychopathology was specific to schizotypy and externalizing behavior, and was not observed for internalizing behaviors (anxiety, withdrawal, depression) or later alcohol use. As such, there is some clinical specificity of the effects of this particular form of early social deprivation to these two forms of psychopathology. It is known that there is comorbidity between schizotypy with aggressive behavior (Raine et al. 2011), although there is relatively limited research on why these two psychopathologies are related. Furthermore, the home alone influence is a "sleeper effect" in that its influence on schizotypy and antisociality does not manifest until later adolescence. Similar sleeper effects have also been found on early childcare and later child development (Belsky et al. 2007). Particularly relevant to the issue of sleeper effects is the English and Romanian Adoptee study (Rutter, 1998) which documented the effects of early institutional deprivation on late-onset psychopathology (sleeper effects) in children adopted into the UK. Comparing the mental health of Romanian children with less than 6 months of early institutional deprivation with UK adoptees (as control) and Romanian adoptees (with more than 6 months of early institutionalization), no difference on emotional symptoms and

conduct problems at ages 11 years and 15 years were observed, but marked increases were found in both domains on parent-reports but not self-reports at age 22-25 years for the Romanian adoptee group (Sonuga-Barke et al., 2017). A similar sleeper effect is seen in our sample where groups did not differ on behavioral symptoms and cognitive performance at age 11 years, but children left home alone at age 3 scored significantly more psychotic symptoms and antisocial behavior at age 17 and 23 years. While early institutional deprivation and subsequent adoption home environments may be quite different to being left home alone with food and water, our results provide addition support that early social deprivation can have late onset effects on adult psychopathology.

An important question concerns how the sleeper effect in our study could be accounted for. Prefrontal dysfunction has been hypothesized as a common denominator to crime and schizophrenia (Cannon & Raine, 2006), and in support of this hypothesis reduced orbitofrontal grey matter volume significantly mediates the crime – schizotypy relationship (Lam, Yang, Raine, & Lee, 2015). Early social isolations could have a long-term neurodevelopmental effect, with the social and executive function demands of late adolescence overloading the later-developing prefrontal cortex. This may in turn give rise a lack of regulatory control, resulting in both antisocial behavior and disorganized schizotypy which was more impaired by being home alone than other schizotypy factors. Abnormal prefrontal-amygdala connectivity has also been associated with both maternal deprivation (Gee et al. 2013) and disruptive behavior disorder (Marsh et al. 2011). Furthermore, support has been documented for a causal model in which emotional (but not physical) neglect is associated with reduced dorsolateral prefrontal grey matter density, which is in turn associated with higher disorganized schizophrenia symptoms (Cancel et al. 2015). A further study comparing children who experienced varying levels of early stress (i.e., early caregiving neglect while living in institutions for orphaned or abandoned children, children

Taken
together, this suggests that (a) limited early social deprivation could have its main impact
later in adolescence via prefrontal dysfunction, (b) disorganized schizotypy may be the factor
of schizotypy most affected as found here, (c) because the prefrontal cortex is still developing
at age 11, early social deprivation may not be as impactful in predisposing to
psychopathology at this earlier age as it is later in adolescence.

This natural experiment was unusual in that the children left home alone were not
undernourished or cognitively impaired. Local staff in Mauritius reported that many parents
were not uncaring or unloving, but had no other alternative given their work and living
circumstances in the 1970s, which may arguably still be true of some families today. There
were cases where children would be tied to the bed before the parents left home, with food
and water placed near to the child, and with ample rope for the child to move around
(personal communication from Cyril Dalais to Adrian Raine, June 2012) - these
circumstances are unimaginable (and illegal) in most developed countries around the world
today. These circumstances without further detailed follow-up do not qualify as complete
neglect as we know it since these parents were concerned about the safety and wellbeing of
their child and may well have proffered considerable attention to their child on their return
home. Perhaps such care though not complete neglect together with ample nutrition provided
may help explain the lack of cognitive and nutritional impairments in this group compared to

findings from other studies, and why no negative short-term psychopathological consequences were observed at age 3 and 11 years. As research has now shown that it is the quality of time spent with child i.e., on unstructured activities (not quality) that matters for children's cognitive development (Hsin & Felfe, 2014).

Implications

Findings from this study may have broader legal and societal implications. In the US, most states do not have laws on leaving children unattended at home. However, in some states it is against the law to leave children unattended at home, although the minimum age of the child being left alone differs across states (Illinois = 14 years, Oregon = 10 years, Maryland = 8 years) (Child Welfare Information Gateway, 2013). In the UK, parents who leave a child unsupervised 'in a manner likely to cause unnecessary suffering or injury to health' may be prosecuted for neglect (Children and Young Persons Act England and Wales, 1933). Although fewer parents may be leaving young children home alone today, the increase in both working mothers and fathers in recent decades has resulted in more "latchkey" children who engage in self-care and spend more time home alone than other children (Lopoo, 2005). For example, in 2013, 64% of mothers who had a child under the age of six years were employed (US Bureau of Labor Statistics, 2014) and their children on average spend nine fewer hours a week in unstructured play with them than with stay-at-home mothers (Hsin & Felfe, 2014). What effect this has on development of later psychopathology is debatable. Home alone children are more likely to harm others (Aizer, 2004), but as with other studies the social effect of isolation was not disentangled from other confounds. Earlier work argued that children in childcare are more likely to be rated by teachers as having more externalizing behavior problems (Belsky et al. 2007) and these small but significant effects

have been substantiated (Huston et al. 2015), although positive effects of being in childcare have also been observed (Belsky et al. 2007).

We recognize that leaving children unattended at home is a sensitive and nuanced issue, and we caution that our findings on being left home alone represent a different social context to childcare. Nonetheless, given the trend towards a reduction in stay-at-home carers, these findings deserve great attention. Current policies on workplace childcare and play schemes might be reconsidered in the light of the broader literature on childcare, particularly for the underserved segments of the population and for those with limited childcare benefits.

Limitations

Several limitations of this study should be recognized. First, as with all birth cohort studies there was no random assignment to being left home alone, and as such causality cannot be claimed. Second, although the total sample size is large (1,794), inevitably the home alone group exposure is relatively small (34) representing only 1.9% of the total population. At the same time, this should bias the study towards null results whereas positive results in the predicted direction were obtained. Third, we do not have precise knowledge on additional familial characteristics (e.g., history of mental health disorders beyond the first generation, quality of parent-child attachment), although a small percentage (6%) of parents reported as being ill psychiatrically or physically were accounted for in our social adversity index. Fourth, the duration of being left home alone during the first three years and for how long this was maintained after age 3, which could have helped rule out alternative genetic explanations for our results (e.g., parents' level of antisocial behavior) and enabled an examination of the dose-response relationships for duration of being home alone. Fifth, we caution that our findings which emanate from a developing country in sub-continental Africa

cannot at this point in time be generalized directly to developed Western countries, there may be similarities in parental practices today that are undisclosed.

Conclusions

In conclusion, this study provides a novel source of knowledge on the effects of limited social isolation early in life on later psychopathology, free of the confounding effects of cognitive and nutritional deficits. Findings provide a window into understanding the long-term effects of daytime social isolation which in severity lies between orphanage care and day-care. Because this prospective cohort study is unlikely to be repeated in the future due to the unethical nature of manipulating the 'home care' construct, findings need to be treated with caution. At the same time, they provide some insight into a common etiological pathway towards two related adult conditions – schizotypal personality and antisocial behavior – giving rise to the hypothesis that a disturbance in social relations early in life predisposes to both psychopathological conditions in adulthood.

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Figure 1. Mean scores on conduct disorder and psychotic behaviors at age 17 for the Home Care groups, with standard error bars (N=1802).

Figure 2. Mean total schizotypy scores at age 23 for the Home Care groups with standard error bars (N=1174).

Figure 3. Mean Self-Report Crime scores at age 23 by Home Care groups with standard error bars (N=1222).

Table 1. Kendall's tau-b and Spearman's Rho correlations between all study variables.

Table 2. Means and standard deviations on behavioral outcome measures for Home Alone, Sibling-Care, and Mother-Care groups for the three assessment periods, together with statistical comparisons and effect sizes.

eTable1. Data available by group.

eTable2. The Social Adversity Index (SAI) is composed of 14 indicators (see Raine, Yaralian, Reynolds, Venables, & Mednick, 2002) collected by social workers who visited the homes of the children at age 11 years. A total adversity score was created by adding 1 point for each of the 14 variables.

eTable 3. Means and standard deviations on behavioral outcome measures for Home Alone, Sibling-Care, and Mother-Care groups at age 11, 17, and 23 together with statistical comparisons and effect sizes after imputation of missing data using expectation-maximization ($N = 1754$).

eTable 4. Means and standard deviations (in brackets) on behavioral outcome measures for Home Alone ($n = 34$), Sibling-Care ($n = 63$), Relative-Care ($n = 159$), and Mother-Care ($n = 1498$) groups at age 11, 17 and 23 together with statistical comparisons and effect sizes after missing imputation using expectation-maximization ($N = 1754$).

Figure 1. Mean scores on conduct disorder and psychotic behaviors at age 17 for the Home Care groups, with standard error bars (N=1802).
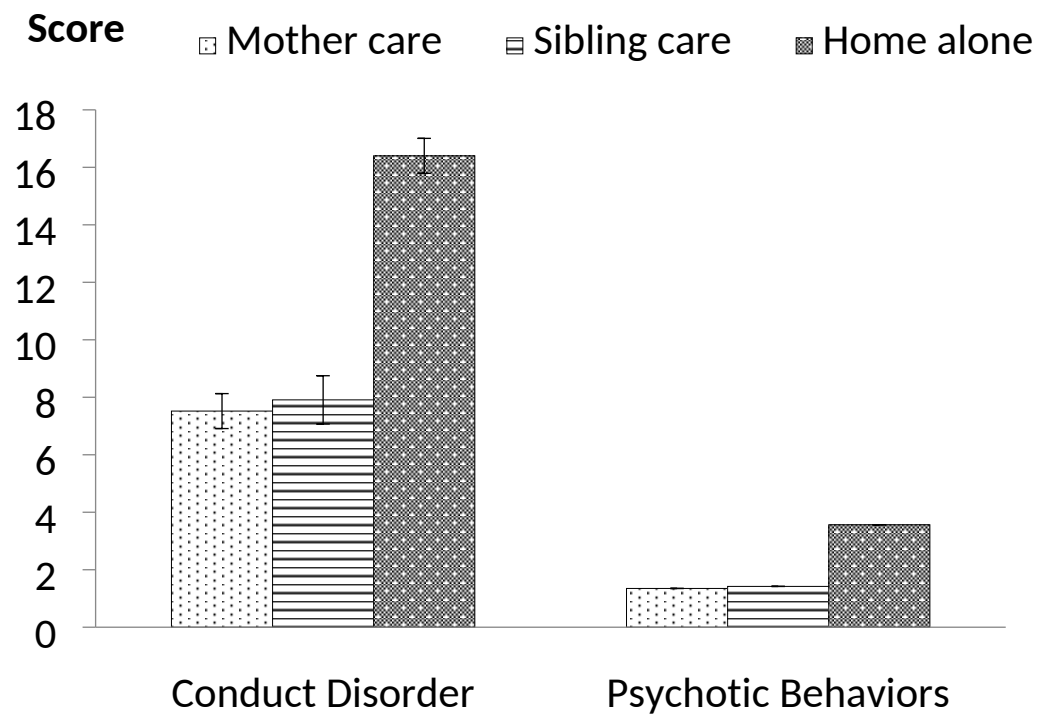
Figure 2. Mean total schizotypy scores at age 23 for the Home Care groups with standard error bars (N=1174).
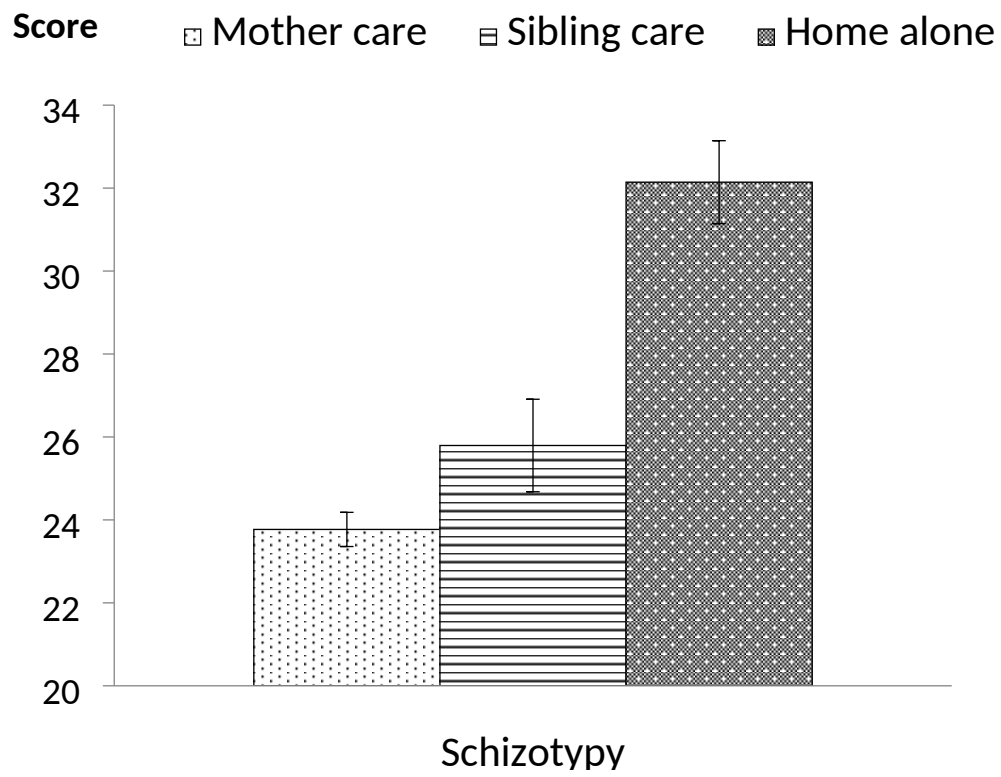
Figure 3. Mean Self-Report Crime scores at age 23 by Home Care groups with standard error bars (N=1222).
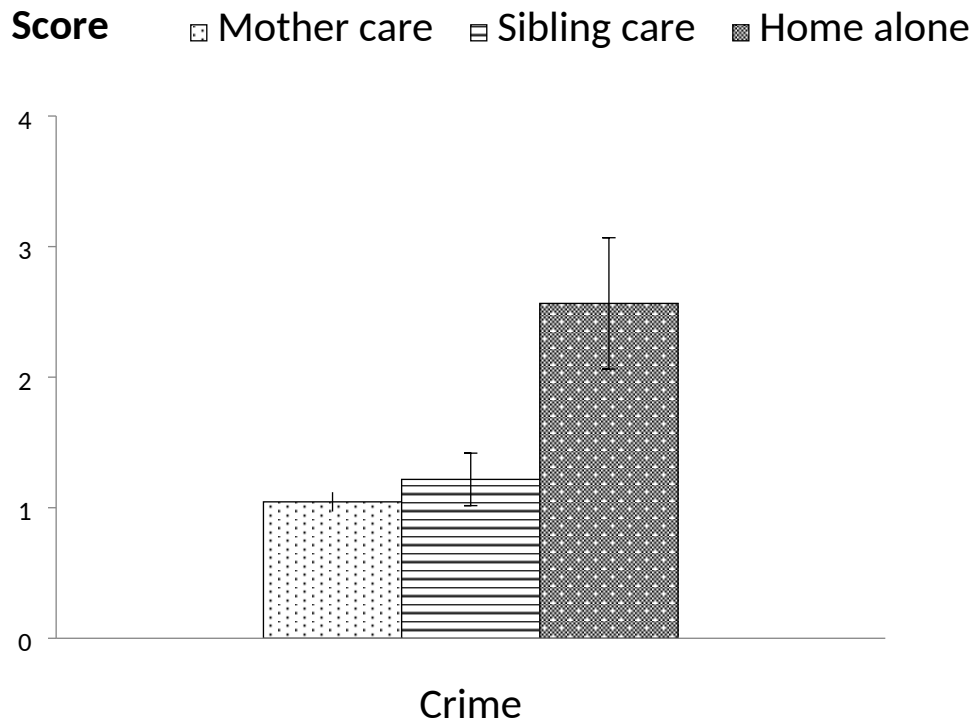
Table 1. Kendall's tau-b and Spearman's Rho correlations between all study variables.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1. Home Care (Mother [0], Alone [1], Sibs/Relatives [2])	-	.01	.11**	.14**	.02	.00	.00	.00	.02	.03	.03	.02	.00	.01	.04*	.03	.01	.05*	.00	.03	.05**	.06**	-.06**	.10**	.04*	.02	.04	.07**	.04	.04	-.05*
2. Sex (male = 0; 51.5%)		-	.00	.01	.03	.05*	-.04	-.18**	-.10**	-.08**	.20**	.09**	-.20**	.05*	-.01	-.04	-.07**	.00	.04*	-.04*	.07**	.02	.04*	.07**	.03	-.03	.06**	-.01	-.26**	.18**	.26**
3. Ethnicity (Hindu/tamil/muslims[0], Creole [1], Chinese [2], English/French/Other [3])			-	-.10**	.04*	.01	.03	.05*	.12**	.14**	.08**	.09**	.10**	.07**	.06**	.02	.03	.02	-.01	.01	.07**	.11**	.01	.02	.04*	.03	.04	.06**	.05*	.00	-.15**
4. Social Adversity				-	-.21**	-.09**	-.28**	-.31**	-.08**	-.02	-.06**	-.08**	-.05*	.00	.07**	.10**	-.01	.02	.01	.13**	.28**	.25**	.14**	.28**	.08**	.03	.09**	.09**	-.01	.08**	.01
5. Verbal IQ (BTBC)					-	.41**	.24**	.23**	.02	.03	.04	.02	.03	-.01	-.01	-.02	.01	-.03	-.07*	-.06*	-.11**	-.10**	-.06*	-.10**	-.03	.02	-.05	-.04	.01	-.01	.04
6. Spatial IQ (BTBC)						-	.13**	.24**	.03	.00	.06*	.03	.03	.00	-.04	-.02	.00	-.02	-.05*	-.08**	-.02	-.02	.04	-.05	-.03	.00	-.04	-.05	.00	-.03	-.01
7. Verbal IQ (WISC)							-	.60**	.00	-.07*	.03	.00	-.02	-.08**	-.15**	-.14**	-.01	-.08**	-.07*	-.20**	-.15**	-.13**	-.08**	-.15**	-.05	.04	-.09**	-.08**	.04	-.04	-.02
8. Spatial IQ (WISC)								-	.04	-.06*	-.03	-.06	.03	-.07**	-.09**	-.08**	.03	-.06*	-.04	-.17**	-.19**	-.16**	-.09**	-.19**	-.09**	.04	-.13**	-.11**	.09**	-.11**	-.07
9. Aggression (CBCL)									-	.64**	.30**	.42**	.42**	.16**	.09**	.04	.07**	.05	.03	.00	.01	.03	.01	-.01	.03	.03	.01	.05*	.11**	.00	-.06*
10. Deliquency (CBCL)										-	.32**	.40**	.44**	.23**	.07**	.06**	.07**	.05*	.01	.02	.08**	.07**	.06*	.06**	.07**	.05*	.06*	.07**	.09**	.03	-.05*
11. Schizoid (CBCL)											-	.56**	.27**	.24**	.04	.03	.04	.04	.04	-.06*	.07**	.05*	.06**	.07**	.10**	.07**	.10**	.06*	-.03	.12**	.03
12. Anxiety (CBCL)												-	.53**	.34**	.05*	.03	.06*	.06**	.03	-.04	.03	.03	.03	.00	.07**	.06*	.07**	.06*	.03	.07**	-.04
13. Depression (CBCL)													-	.29**	.07**	.06*	.07**	.07**	.04	.03	.01	.03	.07**	-.02	.05*	.05*	.05*	.04	.10**	-.05*	-.15**
14. Withdrawn (CBCL)														-	.08**	.04	-.01	.04	.00	.01	.07**	.04	.08**	.06**	.08**	.06*	.08**	.07**	.03	.06*	-.04
15. Conduct Disorder (RBCP)															-	.55**	.39**	.42**	.33**	.53**	.08**	.08**	.04	.07**	.06*	.04	.03	.08**	.04	.04	-.02
16. Psychotic Behavior (RBCP)																-	.34**	.48**	.38**	.38**	.12**	.11**	.04	.10**	.09**	.07**	.06**	.11**	.00	.06*	.01
17. Socialized Aggression (RBCP)																	-	.38**	.27**	.14**	.01	.03	.00	-.01	.03	.04	.01	.04	.06**	.00	-.03
18. Attention Problem (RBCP)																		-	.46**	.20**	.06*	.08**	.01	.04	.08**	.06*	.06*	.07**	.02	.08**	-.03
19. Anxiety-Withdrawal (RBCP)																			-	.23**	.10**	.09**	.09**	.06**	.08**	.05*	.08**	.08**	-.07**	.10**	.02
20. Motor Excess (RBCP)																				-	.09**	.12**	.00	.08**	.07**	.02	.07**	.11**	-.01	.01	-.03
21. Schizotypy (SAE)																					-	.78**	.63**	.85**	.50**	.38**	.49**	.46**	.06*	.32**	-.02
22. SAE Cognitive Perceptual																						-	.29**	.53**	.46**	.41**	.41**	.44**	.07**	.28**	-.06*
23. SAE Interpersonal																							-	.46**	.32**	.21**	.35**	.24**	.00	.20**	-.04
24. SAE Disorganized																								-	.44**	.31**	.45**	.42**	.07**	.28**	-.01
25. Schizotypy (SPQ)																									-	.83**	.87**	.83**	.18**	.55**	-.12**
26. SPQ Cognitive Perceptual																										-	.62**	.62**	.21**	.43**	-.13**
27. SPQ Interpersonal																											-	.67**	.09**	.52**	-.07**
28 SPQ Disorganized																												-	.18**	.47**	-.16**
29. Self-reported Crime																													-	.02	-.22**
30. Depression (BDI)																														-	-.04
31. Alcohol Consumption (MAST)																															-

(Left-margin age groupings: Age 3 — variables 1–6; Age 11 — variables 7–14; Age 17 — variables 15–24; Age 23 — variables 25–31.)

Notes. **. p<.01. *. p<.05. This table depicts Pearson's correlation (normal continuous variables), Spearman's Rho correlations (skewed variables), and Kendall-Tau's correlations (categorical and continuous variables). BTBC = Boehm Test of Basic Concepts–Preschool Version (Boehm, 1986); WISC = Wechsler Intelligence Scale for Children (Wechsler, 1967); CBCL = Child Behavior Checklist (Achenbach et al., 1987); RBCP = Revised Behavioral Problems (Quay & Peterson, 1987; SAE = The Schedule for Attitudes and Experiences (Venables, 1989); SPQ = Schizotypal Personality Questionnaire (Raine, 1991); BDI = Beck's Depression Inventory (Beck et al., 1961); MAST = Michigan Alcohol and Substance Use Test (Selzer, 1971). N=1794.

Table 2. Means and standard deviations on behavioral outcome measures for Home Alone, Sibling-Care, and Mother-Care groups for the three assessment periods, together with statistical comparisons and effect sizes.

	Home alone (SD)	Sibling care (SD)	Mother care (SD)	F(df, n)	Partial η^2	Cohen's d (Alone – Mother care groups)	Cohen's d (Alone – Sibling care groups)
Key outcomes							
Age 11							
Aggression (CBCL)	5.72 (3.79)	4.82 (3.62)	4.60 (3.58)	F(2, 1181) = 1.19	.002		
Delinquency (CBCL)	5.56 (3.38)	4.99 (3.29)	4.69 (3.38)	F(2, 1181) = .63	.001		
Anxiety (CBCL)	4.00 (2.63)	3.65 (2.71)	3.59 (2.71)	F(2, 1181) = .38	.001		
Schizoid traits (CBCL)	2.94 (2.31)	2.83 (2.04)	2.56 (1.95)	F(2, 1181) = 1.78	.003		
Depression (CBCL)	7.44 (2.66)	6.77 (3.49)	6.84 (3.71)	F(2, 1181) = .28	.000		
Withdrawn (CBCL)	2.17 (1.42)	2.24 (1.93)	2.27 (2.01)	F(2, 1181) = .14	.000		
Age 17							
Conduct disorder (RBPC)	16.40 (12.64) [a]	7.91 (7.05)	7.52 (7.49)	F(2, 591) = 6.17**	**.021**	**.830**	**.855**
Psychotic behavior (RBPC)	3.60 (3.60) [a]	1.41 (1.82)	1.35 (1.91)	F(2, 591) = 6.20**	**.021**	**.768**	**.781**
Socialized aggression (RBPC)	3.90 (5.11)	1.70 (2.22)	1.82 (2.80)	F(2, 591) = 2.90	.010		
Attention problem (RBPC)	10.80 (8.04)	7.58 (5.30)	6.98 (5.58)	F(2, 591) = 2.23	.008		
Anxiety – withdrawal (RBPC)	7.20 (4.10)	5.47 (3.75)	5.59 (3.87)	F(2, 591) = .92	.003		
Motor excess (RBPC)	5.10 (2.28)	3.36 (2.72)	3.38 (2.75)	F(2, 591) = 2.25	.008		
Schizotypy (SAE)	22.50 (3.21)	20.71 (2.72)	20.89 (2.86)	F(2, 650) = 2.17	.007		
SAE Cognitive-Perceptual	8.40 (1.17)	7.67 (1.55)	7.75 (1.40)	F(2, 650) = 1.58	.005		
SAE Interpersonal	6.20 (1.40)	5.59 (1.03)	5.80 (1.04)	F(2, 650) = 2.43	.007		
SAE Disorganized	7.90 (1.52)	7.45 (1.30)	7.34 (1.41)	F(2, 650) = .57	.002		
Age 23							
Schizotypy (SPQ)	32.14 (13.67) [b]	25.79 (14.60)	23.77 (12.91)	F(2, 1174) = 3.79*	**.006**	**.449**	
SPQ Cognitive-Perceptual	14.48 (6.15) [b]	11.34 (6.82)	11.01 (5.99)	F(2, 1174) = 3.01*	**.005**	**.484**	
SPQ Interpersonal	15.14 (7.28)	13.16 (6.90)	12.22 (6.65)	F(2, 1174) = 1.64	.003		
SPQ Disorganized	7.52 (4.31) [b]	5.40 (4.27)[b]	4.43 (3.82)	F(2, 1174) = 7.17**	**.012**	**.494**	

Self-report crime	2.57 (4.05) [a]	1.22 (2.73)	1.05 (2.30)	$F(2, 1225) = 4.73^{**}$	**.008**	**.391**	**.462**
Depression (BDI)	11.65 (9.01)	11.00 (9.21)	9.98 (9.08)	$F(2, 1237) = .49$	.001		
Alcohol consumption (MAST)	46.11 (3.11)	46.15 (2.73)	46.73 (2.73)	$F(2, 1090) = 1.87$	.003		
Adversity, nutrition, & IQ							
Social Adversity Index (SAI)	2.65 (1.35) [b]	2.41 (1.54)	1.81 (1.31)	$F(2, 1754) = 26.68$	**.030**[***]	**.166**	**.632**
Nutrition at age 3	.02 (.14)	-.00 (.14)	.00 (.13)	$F(2, 1754) = .47$	.001		
Fearlessness at age 3	-.01 (.93)	-.02 (.83)	-.00 (.81)	$F(2, 1723) = .04$	.000		
Stimulation seeking at age 3	-.04 (.66)	-.01 (.71)	-.06 (.67)	$F(2, 1723) = .58$	.001		
Verbal IQ at age 3 (BTBC)	102.23 (16.00)	100.17 (14.84)	99.60 (14.95)	$F(2, 1351) = 1.75$	.003		
Spatial IQ at age 3 (BTBC)	104.26 (16.73)	99.13 (14.13)	99.76 (15.05)	$F(2, 1351) = 1.61$	.002		
Verbal IQ at age 11 (WISC)	100.99 (16.33)	99.64 (15.57)	99.79 (14.80)	$F(2, 1232) = .99$	.002		
Spatial IQ at age 11 (WISC)	97.70 (16.15)	99.66 (16.82)	99.68 (14.53)	$F(2, 1232) = 1.05$	.002		

Note. [*] $p < .05$; [**] $p < .01$; [***] $p < .001$ [a] = significant difference with sibling-care and mother-care groups. [b] = significant group difference with mother care group only. CBCL = Child Behavior Checklist (Achenbach); RBPC = Revised Behavior Problem Checklist (Quay & Peterson, 1987); SAE = Schedule for Attitudes and Experiences (Venables, Wilkins, Mitchell, Raine, & Bailes, 1990); SPQ = Schizotypal Personality Questionnaire (Raine, 1991); MAST = Michigan Alcohol and Substance Use Test (Seltzer, 1971); BDI = Beck's Depression Inventory (Beck, Ward, Mendelsohn, Mock, & Erbaugh, 1961); SAI = Social Adversity Index made up of 14 indicators (see Raine, Yaralian, Reynolds, Venables, & Mednick, 2002); BTBC = Boehm Test of Basic Concepts – Preschool Version (Boehm, 1986); WISC = Wechsler Intelligence Scale for Children (Wechsler, 1967). All analyses control for ethnicity and social adversity. All significant contrasts remained significant with post-hoc Bonferroni corrections.

Conflict of interest

The authors declare no conflict of interest.

eTable1. Data available by group.

Variables	Home Alone (*n* = 34)		Sibling-Care (*n* = 222)		Mother-Care (*n* =1498)	
	%		*%*		*%*	
Demographics						
Gender (%male)	64.7		48.2		52.3	
Ethnicity						
Hindu/Tamil/Muslims (0)	52.9		56.3		71.7	
Creole (1)	38.2		39.2		23.0	
Chinese (2)	8.8		1.4		1.3	
English/French/Other/Uncertain (3)	0.0		3.2		3.9	
	Home Alone (*n* = 34)		**Sibling-Care (*n* = 222)**		**Mother-Care (*n* =1498)**	
Age 11[a]	*n*	Miss.	*n*	Miss.	*n*	Miss.
Aggression (CBCL)	18	16	141	81	1022	476
Delinquency (CBCL)	18	16	141	81	1022	476
Schizoid traits (CBCL)	18	16	141	81	1022	476
Anxiety (CBCL)	18	16	141	81	1022	476
Depression (CBCL)	18	16	141	81	1022	476
Withdrawal (CBCL)	18	16	141	81	1022	476
Age 17[b]						
Conduct disorder (RBPC)	10	24	81	141	500	998
Socialized aggression (RBPC)	10	24	81	141	500	998
Attention problems (RBPC)	10	24	81	141	500	998
Anxiety withdrawal (RBPC)	10	24	81	141	500	998
Psychotic behavior (RBPC)	10	24	81	141	500	998

Motor excess (RBPC)	10	24	81	141	500	998
Schizotypy total (SAE)	10	24	75	147	565	933
Disorganized (SAE)	10	24	75	147	565	933
Interpersonal (SAE)	10	24	75	147	565	933
Cognitive-Perceptual (SAE)	10	24	75	147	565	933
Age 23[c]						
Self-report crime	23	11	147	75	1055	443
SPQ total	21	13	141	81	1012	486
Cognitive-perceptual	21	13	141	81	1012	486
Interpersonal	21	13	141	81	1012	486
Disorganized	21	13	141	81	1012	486
Depression (BDI)	23	11	148	74	1066	432
Alcohol consumption (MAST)	19	15	132	90	939	559
Adversity, nutrition, & IQ						
Social Adversity Index (SAI)	19	15	154	68	1072	426
Nutrition at age 3	34	0	222	0	1498	0
Verbal IQ at age 3 (BTBC)	27	7	172	50	1155	343
Spatial IQ at age 3 (BTBC)	27	7	180	42	1209	289
Verbal IQ at age 11 (WISC)	18	16	157	65	1057	441
Spatial IQ at age 11 (WISC)	18	16	157	65	1057	441

SAE = Survey of Attitudes and Experiences; RBPC = Revised Behavior Problem Checklist; SPQ = Schizotypal Personality Questionnaire; SAI = Social Adversity Index made up of 14 indicators (see Raine, Yaralian, Reynolds, Venables, & Mednick, 2002). [a] = 54.4% are male; [b] = 53.5% are male; [c] = 58.4% are male.

eTable 2. The Social Adversity Index (SAI) is composed of 14 indicators (see Raine, Yaralian, Reynolds, Venables, & Mednick, 2002) collected by social workers who visited the homes of the children at age 11 years. A total adversity score was created by adding 1 point for each of the following 14 variables:

1. living in rented accommodation (20.7%)
2. house without electricity or water (15.6%)
3. child has neither good toys nor good books (35.7%)
4. no television (22.5%)
5. living in poor housing (24.7%)
6. father uneducated (30.0%)
7. mother uneducated (29.4%)
8. parent psychiatrically ill (4.0%)
9. parent physically ill (2.0%)
10. teenage mother (age 19 years or younger when child was born, 14.2%)
11. single-parent status (8.3%)
12. separation from both parents (1.1%)
13. five or more siblings (30.7%)
14. over- crowded home (five or more family members per house room, 12.1%).

Scores ranged from 0 to 6 ($M = 2.04$, $SD = 1.61$).

eTable 3. Means and standard deviations (in brackets) on behavioral outcome measures for Home Alone (n = 34), Sibling/Relative Care (n = 222), and Mother Care (n = 1498) groups at age 11, 17 and 23 together with statistical comparisons and effect sizes after missing imputation using expectation-maximization (N = 1754).

	Home alone (SD)	Sibling care (SD)	Mother care (SD)	F(df, n)	Partial η^2	Cohen's d (Alone – Mother care groups)	Cohen's d (Alone – Sibling care groups)
Key outcomes							
Age 11							
Aggression (CBCL)	5.21 (2.77)	4.75 (2.88)	4.60 (2.96)	F(2, 1751) = .88	.001		
Delinquency (CBCL)	5.17 (2.46)	4.90 (2.62)	4.70 (2.79)	F(2, 1751) = .90	.001		
Schizoid traits (CBCL)	2.78 (1.67)	2.74 (1.63)	2.57 (1.61)	F(2, 1751) = 1.34	.002		
Anxiety (CBCL)	3.81 (1.90)	3.63 (2.16)	3.59 (2.24)	F(2, 1751) = .18	.000		
Depression (CBCL)	7.15 (1.94)	6.79 (2.78)	6.83 (3.06)	F(2, 1751) = .21	.000		
Withdrawal (CBCL)	2.22 (1.02)	2.25 (1.53)	2.27 (1.66)	F(2, 1751) = .04	.000		
Age 17							
Conduct disorder (RBPC)	10.27 (7.73) [a]	7.78 (4.25)	7.64 (4.32)	F(2, 1751) = 5.92**	**.007**	**.399**	**.420**
Psychotic behavior (RBPC)	2.04 (2.14) [a]	1.40 (1.10)	1.38 (1.10)	F(2, 1751) = 5.75**	**.007**	**.376**	**.388**
Socialized aggression (RBPC)	2.47 (2.83)	1.81 (1.34)	1.85 (1.62)	F(2, 1751) = 2.52	.003		
Attention problem (RBPC)	8.24 (4.52)	7.32 (3.19)	7.11 (3.22)	F(2, 1751) = 2.34	.003		
Anxiety – withdrawal (RBPC)	6.10 (2.26)	5.58 (2.25)	5.63 (2.23)	F(2, 1751) = .81	.001		
Motor excess (RBPC)	3.89 (1.43)	3.38 (1.64)	3.38 (1.59)	F(2, 1751) = 1.71	.002		
Schizotypy (SAE)	21.84 (1.96) [b]	21.05 (1.85)	20.89 (1.93)	F(2, 1751) = 4.49*	**.005**	.488	
SAE Cognitive-Perceptual	8.19 (.76) [b]	7.82 (.99)	7.75 (.92)	F(2, 1751) = 4.18*	**.005**	.522	
SAE Interpersonal	5.82 (.80)	5.69 (.63)	5.79 (.67)	F(2, 1751) = 2.31	.003		
SAE Disorganized	7.83 (.89) [b]	7.54 (.84) [b]	7.36 (.93)	F(2, 1751) = 7.86**	**.009**	.516	
Age 23							
Schizotypy (SPQ)	28.65 (11.66) [b]	25.08 (11.70)	23.68 (10.65)	F(2, 1750) = 4.89**	**.006**	.445	
Cognitive-perceptual	13.00 (5.19)	11.18 (5.45)	10.94 (4.97)	F(2, 1750) = 2.51	.003		
Interpersonal	13.76 (5.99)	12.71 (5.54)	12.08 (5.52)	F(2, 1750) = 1.32	.002		
Disorganized	6.09 (3.85) [b]	4.88 (3.47)	4.26 (3.18) [c]	F(2, 1750) = 5.87**	**.007**	.518	

Self-report crime	2.06 (3.39)[a]	1.14 (1.03)	1.03 (1.94)	$F(2, 1751) = 4.50^{*}$	**.005**	**.373**	**.367**
Depression (BDI)	11.12 (7.40)	10.67 (7.52)	9.98 (7.66)	$F(2, 1751) = 1.08$	.001	
Alcohol consumption (MAST)	46.00 (2.34)	46.10 (2.11)	46.49 (2.20)[c]	$F(2, 1751) = 3.70^{*}$	.004	

Note. * $p < .05$; ** $p < .01$; *** $p < .001$. [a] = significant difference with Sibling-Care and Mother-Care groups. [b] = significant group difference with Mother-Care group only. [c] = significant group contrasts with the Sibling/Relative-Care group. *Ns* = 34 (Home alone), 222 (Sibling care), 1498 (Mother care). Age 17 Little's MCAR = $\chi^2(df)=327.38(295)$, $p=.09$. Age 23 Little's MCAR = $\chi^2(df)=35.01(30)$, $p=.24$. CBC = Child Behavior Checklist (Achenbach); RBPC = Revised Behavior Problem Checklist (Quay & Peterson, 1987); SAE = Schedule for Attitudes and Experiences (Venables, Wilkins, Mitchell, Raine, & Bailes, 1990). All analyses control for ethnicity and social adversity. All significant contrasts remained significant with post-hoc Bonferroni corrections. 52.0% are male in the full imputed sample.

eTable 4. Means and standard deviations (in brackets) on behavioral outcome measures for Home Alone (n = 34), Sibling-Care (n = 63), Relative-Care (n = 159), and Mother-Care (n = 1498) groups at age 11, 17 and 23 together with statistical comparisons and effect sizes after missing imputation using expectation-maximization (N = 1754).

	Home alone (SD)	Sibling-Care (SD)	Relative-Care (SD)	Mother-Care (SD)	F(df, n)	Partial η^2	Cohen's d (Alone – Mother Care group)	Cohen's d (Alone – Sibling Care group)
Key outcomes								
Age 11								
Aggression (CBCL)	5.21 (2.77)	4.34 (2.68)	4.91 (2.95)	4.60 (2.96)	F(3, 1750) = 1.15	.002		
Delinquency (CBCL)	5.17 (2.46)	4.41 (2.33)	5.09 (2.71)	4.70 (2.79)	F(3, 1750) = 1.51	.003		
Schizoid traits (CBCL)	2.78 (1.67)	2.23 (1.40)	2.95 (1.67)[a]	2.57 (1.61)	F(3, 1750) = 3.89**	**.007**		
Anxiety (CBCL)	3.81 (1.90)	3.06 (2.04)	3.85 (2.16)	3.59 (2.24)	F(3, 1750) = 1.07	.004		
Depression (CBCL)	7.15 (1.94)	6.13 (2.46)	7.05 (2.86)	6.83 (3.06)	F(3, 1750) = 1.54	.003		
Withdrawal (CBCL)	2.22 (1.02)	2.21 (1.30)	2.27 (1.62)	2.27 (1.66)	F(3, 1750) = .05	.000		
Age 17								
Conduct disorder (RBPC)	10.27 (7.73)[a]	8.28 (4.56)	7.58 (4.10)[c]	7.64 (4.32)	F(3, 1750) = 4.33**	**.007**	**.399**	**.420**
Psychotic behavior (RBPC)	2.04 (2.14)[a]	1.37 (1.12)	1.41 (1.09)[c]	1.38 (1.10)	F(3, 1750) = 3.86**	**.007**	**.376**	**.388**
Socialized aggression (RBPC)	2.47 (2.83)	1.97 (1.66)	1.75 (1.18)	1.85 (1.62)	F(3, 1750) = 1.97	.003		
Attention problem (RBPC)	8.24 (4.52)	7.06 (3.58)	7.43 (3.03)	7.11 (3.22)	F(3, 1750) = 1.75	.003		
Anxiety – withdrawal (RBPC)	6.10 (2.26)	5.74 (2.06)	5.52 (2.33)	5.63 (2.23)	F(3, 1750) = .69	.001		
Motor excess (RBPC)	3.89 (1.43)	3.76 (1.62)	3.23 (1.62)	3.38 (1.59)	F(3, 1750) = 2.83	.005		
Schizotypy (SAE)	21.84 (1.96)[b]	21.32 (1.84)	20.94 (1.84)[c]	20.89 (1.93)	F(3, 1750) = 3.58*	.006	**.488**	
SAE Cognitive-Perceptual	8.19 (.76) [a]	7.88 (1.06)	7.80 (.96)[c]	7.75 (.92)	F(3, 1750) = 2.90*	.005	**.510**	
SAE Interpersonal	5.82 (.80)	5.62 (.65)[b]	5.72 (.62)	5.79 (.67)	F(3, 1750) = 1.91	.003		
SAE Disorganized	7.83 (.89)	7.83 (.84)	7.43 (.82)[c]	7.36 (.93)	F(3, 1750) = 8.12**	.014	**.516**	
Age 23								
Schizotypy (SPQ)	28.65 (11.66)[b]	24.83 (13.00)	25.18 (11.19)	23.67 (10.65)	F(3, 1750) = 3.29*	.006	**.446**	
Cognitive-perceptual	13.00 (5.19)	10.81 (5.76)	11.33 (5.33)	10.94 (4.97)	F(3, 1750) = 2.12	.004		

Interpersonal	13.76 (5.99)	12.94 (5.80)	12.62 (5.45)	12.08 (5.52)	$F(3, 1750) = 1.80$	.003	
Disorganized	6.09 (3.85)[b]	4.84 (4.05)	4.90 (3.23)	4.26 (3.18)	$F(3, 1750) = 5.67^{**}$	**.010**	**.518**
Self-report crime	2.06 (3.39)[a]	.86 (1.34)	1.25 (2.49)	1.03 (1.94)	$F(3, 1750) = 3.58^{*}$	**.006**	**.373**	**.367**
Depression (BDI)	11.12 (7.40)	9.65 (7.60)	11.07 (7.48)	9.98 (7.66)	$F(3, 1750) = 1.24$	.002	
Alcohol consumption (MAST)	46.00 (2.34)	46.25 (1.95)	46.04 (2.17)	46.49 (2.20)	$F(3, 1750) = 2.61$	.004	

Note. $^{*} p < .05$; $^{**} p < .01$; $^{***} p < .001$. [a] = significant difference with Sibling-Care and Mother-Care groups. [b] = significant difference with Mother-Care group only. [c] = significant difference with home alone group. *Ns* = 34 (Home alone), 159 (Relative-Care), 63 (Sibling-Care), 1498 (Mother-Care). Age 17 Little's MCAR = $\chi^2(df)=327.38(295)$, *p*=.09. Age 23 Little's MCAR = $\chi^2(df)=35.01(30)$, *p*=.24. CBCL = Child Behavior Checklist (Achenbach et al., 1987); RBPC = Revised Behavior Problem Checklist (Quay & Peterson, 1987); SAE = Schedule for Attitudes and Experiences (Venables, Wilkins, Mitchell, Raine, & Bailes, 1990). All analyses control for ethnicity and social adversity. All significant contrasts remained significant with post-hoc Bonferroni corrections. 52.5% are male in the full imputed sample.