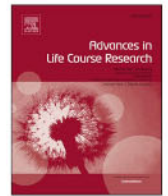


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Do socially isolated children become socially isolated adults?

Roy Lay-Yee^{a,*}, Timothy Matthews^b, Terrie Moffitt^c, Richie Poulton^d, Avshalom Caspi^c, Barry Milne^{a,e}^a Centre of Methods and Policy Application in the Social Sciences, Faculty of Arts, University of Auckland, New Zealand^b Department of Social, Genetic & Developmental Psychiatry, Institute of Psychiatry, King's College London, United Kingdom^c Department of Psychology & Neuroscience, Duke University, Durham, NC, United States^d Department of Psychology, University of Otago, Dunedin, New Zealand^e Department of Statistics, Faculty of Science, University of Auckland, New Zealand

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ABSTRACT

Social isolation - the lack of social contacts in number and frequency - has been shown to have a negative impact on health and well-being. Using group-based trajectory analysis of longitudinal data from a New Zealand birth cohort, we created a typology of social isolation based on onset during the life course and persistence into adulthood. We then characterized each type according to risk factors related to family environment and child behavior that have been shown previously to be associated with social isolation. Based on fit statistics and distinctness of trajectories we considered the four-class model to be the most appropriate: (1) 'never isolated' (71.6 % of the cohort), (2) 'adult only' (10.1 %), (3) 'child only' (14.3 %), and (4) 'persistent isolation' (4.0 %). Family-environmental factors - i.e. having a teen-aged mother, having a single parent, frequent changes in residence, or maltreatment - tended to be associated with both child and adult onset and persistence of social isolation, whereas child-behavioral factors - i.e. self-control or internalizing symptoms - applied more to the child onset of social isolation. Sensitivity analyses using empirically defined groups - based on 15 % 'cut-offs' for isolation in childhood and adulthood - produced similar life-course groupings and similar associations. Our findings provide insights into the development of social isolation and demonstrate the changeability of social isolation across almost four decades of the life span. They also suggest family-based and child-based interventions could address child onset and the persistence of social isolation into adulthood.

1. Introduction

Social relationships are central to the health and well-being of both individuals and the communities in which they live. An acute marker of social connectedness is the degree to which an individual is isolated, i.e. lacking contact with others (Cacioppo et al., 2011; de Jong Gierveld et al., 2016d). Particularly in developed countries (such as New Zealand), there has been growing recognition of social isolation as a significant public threat - affecting both mental and physical health - that requires organized intervention at a societal level (Holt-Lunstad et al., 2017; Leigh-Hunt et al., 2017). Moreover, the Covid-19 pandemic - with its forced strictures of distancing and quarantine - has heightened concerns about the long term impacts of social isolation (Pietrabissa & Simpson, 2020; Settersten et al., 2020; Smith & Lim, 2020).

Though concern has focused more on older people (e.g. Courtin & Knapp, 2017), social isolation can affect individuals at any age. Across

the life course, the experience of social isolation can vary as each life stage has its own related circumstances and trials (de Jong Gierveld et al., 2016d). Questions of timing are crucial to understanding the complexity of social isolation and its effects. As well as being ubiquitous, social isolation may have an earlier or later onset in life, and it may be transient or prolonged in duration. Social isolation occurring in childhood may have continuing adverse effects as children develop into adults (Danese et al., 2009). Therefore, a life-course perspective is advantageous in accounting for both earlier and concurrent influences, and indicating possible points for intervention to reduce risk or to build resilience (Hunt, 2005; Luthar, 2003).

In children, family environment and child socio-emotional factors have been associated with social isolation. For example, it has been found that socially withdrawn children were more likely to come from families of low socio-economic status (Schneider et al., 2000), that children were less socially competent and more socially disconnected if

* Corresponding author at: COMPASS Research Centre, University of Auckland, Private Bag 92019, Auckland, 1142, New Zealand.
E-mail address: r.layyee@auckland.ac.nz (R. Lay-Yee).

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their parental relationships were poor (Repetti et al., 2002), and that children who have been physically maltreated or who have mental health difficulties were at greater risk of being socially isolated (Matthews et al., 2015). There is evidence that social isolation has negative consequences both for the child's social and emotional functioning (Bukowski & Adams, 2005; Coplan et al., 2018; Laursen et al., 2007; Marryat et al., 2014), and for the health of the emergent adult (e.g. cardiovascular disease (Caspi et al., 2006), depression (Danese et al., 2009), hospitalization (Almquist, 2011), inflammation (Lacey et al., 2014), and suicide (Rojas, 2018).

Longitudinal investigations of social isolation from childhood into adulthood are rare (e.g. Caspi et al., 2006). Such studies are important to understand the development of social isolation - the extent to which isolation is transient or persistent, whether risk factors are the same through the life course, and whether negative effects accumulate with extended or recurrent periods of isolation (de Jong Gierveld et al., 2016d). In particular, there is a gap in the investigation of factors that influence the persistence of social isolation from child to adult.

In this paper, we focus on childhood risk factors as they may confer vulnerability to isolation in adulthood, and as they are known to have life-long effects on adult health; for example, perceived social isolation plays a mediating role in the association between childhood physical maltreatment and adult internalizing symptoms (Sheikh, 2018). We aim to investigate patterns of social isolation from childhood to mid-adulthood - i.e. its transience or persistence - by identifying different groups based on these patterns using trajectory modelling, and then characterizing these groups according to family-environmental and child-behavioral risk factors. We replicate analyses using groups defined from measures of social isolation based on cut-offs in childhood and again in adulthood.

We address the following specific research questions:

- 1 Do socially isolated children become isolated adults, or are there distinct 'child-onset' and 'adult-onset' groups? We form these groups based on child isolation and adult isolation, using group-based trajectory modelling. We hypothesize that these 'trajectory' groups have distinct profiles.
- 2 What factors characterize these 'trajectory' groups that represent different patterns of social isolation experienced by children as they become adults? We hypothesize that family-environment and child-behavioral factors are associated with patterns of social isolation in children and adults. We expect that levels of social isolation will be higher in those sub-groups that are more disadvantaged or experience greater levels of dysfunction.

2. Methods

2.1. Data source

We used data from the Dunedin Multidisciplinary Health and Development Study (DMHDS), an ongoing longitudinal investigation of the health and behavior of a complete birth cohort of consecutive births ($N = 1037$) over a one-year period from April 1, 1972 to March 31, 1973 in Dunedin, New Zealand (Poulton et al., 2015). Assessments have been carried out at ages 3, 5, 7, 9, 11, 13, 15, 18, 21, 26, 32, 38, and 45. We focus on assessments through to age 38 which took place in 2010–2012 when 95 % ($n = 961$) of living cohort members participated in the study.

2.2. Outcome variables

Child isolation was assessed by a collection of measures from ages 5–11 (Caspi et al., 2006; Danese et al., 2009). When a study member was 5, 7, 9, and 11 years old, their parent and teacher completed the Rutter Child Scale (Elander & Rutter, 1996), reporting on two items that measure peer problems: 'tends to do things on his/her own; is rather solitary' and 'not much liked by other children'. At each age, scores on

these two scale items (0 = doesn't apply, 1 = applies somewhat, 2 = certainly applies) were averaged across the two reporting sources (i.e. parent and teacher).

Adult isolation was assessed using *informant report* at ages 26, 32 and 38. At each of these ages, up to three informants whom the study member nominated as 'knowing them well' were mailed a questionnaire. At each age, over 90 % of study members had reports from at least two informants and over 60 % had reports from all three informants. At each age, scores on the item 'seems lonely' (0 = not a problem, 1 = bit of a problem, 2 = yes, a problem) were averaged across informants.

2.3. Characteristic domains

2.3.1. Family factors

- (i) A score for *socio-economic status* was estimated as the average of the highest level of either parent using the Elley-Irving scale of occupational socio-economic status (Elley & Irving, 1972) which was assessed repeatedly at the study member's birth and at ages 3, 5, 7, 9, 11, 13, and 15 years. Individual scores were grouped into low (16 %), medium (63 %), and high (21 %) categories. Low socio-economic status of the family has been associated with being socially withdrawn as a child (Schneider et al., 2000). We expect that children from families of lower socio-economic status will experience higher levels, earlier onset, and increased persistence of social isolation.
- (ii) A *teen-aged mother* was defined as being aged 18 or under and coded in a binary variable as 'yes' or 'no'. Teen-aged mothers, compared to older mothers, have been shown to be more deprived, have less access to resources, and to experience worse mental health (Moffitt, 2002), and also to have poorer parenting skills (Lewin et al., 2013). Children of teen-aged mothers, compared to other children, exhibit more behavioral problems and are prone to higher risk of maltreatment (Moffitt, 2002). We expect that children with a teen-aged mother will experience higher levels, earlier onset, and increased persistence of social isolation.
- (iii) We assessed whether the child had a *single parent* for at least one year up to age 11 as a binary variable coded 'yes' or 'no'. Single mothers are more likely to experience low socio-economic status and to suffer from mental distress (Franz et al., 2003). Children raised in single-mother families tend to fare worse with behavioral and mental health problems (Eamon & Zuehl, 2001; Lipman et al., 2002; Waldfogel et al., 2010). We expect that children with a single parent will experience higher levels, earlier onset, and increased persistence of social isolation.
- (iv) We measured *change in residence* as the number of times that this occurred up to age 11. Family instability, particularly high levels of residential instability, is associated with worse child well-being (Waldfogel et al., 2010). We expect that children subject to more frequent changes in residence will experience higher levels, earlier onset, and increased persistence of social isolation.
- (v) The *Family Relationships Index* (FRI) (Holahan & Moos, 1983), derived from the Family Environment Scale (Moos & Moos, 1981) was measured at age 9. The 27-item FRI assesses the quality of family relationships based on the three subscales from the relationship domain of the Family Environment Scale, i.e. cohesion, expressiveness, and (reverse-coded) conflict. Scores were categorized for analysis into quintiles (quintile 1 = lowest quality family relationships; quintile 5 = highest quality family relationships). Poor parental relationship has been shown to be associated with children who were less socially competent and more socially disconnected (Repetti et al., 2002). We expect that children with lower FRI will experience higher levels, earlier onset, and increased persistence of social isolation.

- (vi) An index of *maltreatment* was formed by combining measures of maternal rejection (age 3), harsh discipline (ages 7 and 9), disruptive caregiver changes from birth to age 11, exposure to physical abuse from birth to age 11, and exposure to sexual abuse from birth to age 11 (Caspi et al., 2002). Prior studies have found that children and adolescents who have been physically maltreated were at greater risk of being socially isolated (Elliot et al., 2005; Matthews et al., 2015). On our index, 64.2 % of children experienced 'no' maltreatment, 26.6 % experienced one indicator of maltreatment ('probable'), and 9.2 % experienced two or more indicators of maltreatment ('severe'). For the purpose of analysis, the index was dichotomized as 'no maltreatment' versus 'probable or severe maltreatment'. We expect that children with higher rates of maltreatment will experience higher levels, earlier onset, and increased persistence of social isolation.

2.3.2. Child-behavioral factors

As well as family context, we sought to assess the relationship between social isolation and particular concurrent child-behavioral factors, i.e. self-control, and worry/fearfulness.

- (i) *Self-control* – or the ability to regulate emotions and behavior – was assessed using a scale combining measures of lack of control (ages 3 and 5), impulsivity (ages 5, 7, 9, and 11), and hyperactivity (ages 5, 7, 9, and 11) (Moffitt et al., 2011). The scale was split into quintiles for the purpose of analysis (quintile 1 = highest self-control; quintile 5 = lowest self-control). Children's self-control has been linked with their social status among peers, i.e. rated on whom they would like to play with (Maszk et al., 1999), and to worse later health and well-being (Moffitt et al., 2011). We expect that children with less self-control will experience higher levels, earlier onset, and increased persistence of social isolation.
- (ii) When a study member was 5, 7, 9, and 11 years old, their parent and teacher completed the Rutter Behavior Scales (Elander & Rutter, 1996). Scores on the *worried/fearful* scale – a measure of childhood internalizing symptoms – were averaged across rater and age, and split into quintiles for analysis and interpretation (note, items relating to social isolation were not used in the construction of the worry/fearful scale). Prior research has shown that school-age children who had internalizing symptoms – such as anxiety or depression symptoms – were at greater risk of being socially isolated (Matthews et al., 2015). We expect that children with more internalizing symptoms will experience higher levels, earlier onset, and increased persistence of social isolation.

2.4. Data analysis

We used group-based trajectory modelling to classify individuals exhibiting similar social isolation trajectories over the life course from childhood to adulthood (Nagin & Odgers, 2010; van der Nest et al., 2020v). We assessed goodness of fit for between two and six groups using three criteria: (i) the Bayesian Information Criterion (BIC); (ii) entropy (classification accuracy); and (iii) whether additional groups revealed novel trajectories (as opposed to splitting similar trajectories into two). We restricted analyses to individuals with at least four of seven waves of data available ($n = 992$). Analyses were conducted using the 'traj' package for Stata 16.0 (StataCorp, 2019). We then examined the family and child characteristics of each of these 'trajectory' groups, where significant associations were identified using Pearson's chi-square test ($p < .05$).

For the purpose of sensitivity analysis, we created a typology of four groups of individuals according to patterns of social isolation (by onset and persistence): never isolated (neither isolated as a child nor as an adult); adult onset (first became isolated as an adult), child only (isolated as a child but not as an adult), and child-and-adult (isolated both as

a child and as an adult) – termed 'isolation' groups. To determine isolation status in childhood, the childhood isolation items were averaged across the four time periods (i.e. ages 5, 7, 9, and 11), and by the two reporting sources (i.e. parent and teacher) (Cronbach $\alpha = 0.77$). The top 15 % of scores were designated as 'isolated' (actual percentage in this group was 14.8 %). Similarly, to determine isolation status in adulthood, the adult isolation items were averaged across informants and across ages 26, 32 and 38 (Cronbach $\alpha = 0.73$), and the top 15 % of scores were designated as 'isolated' (actual percentage in this group was 16.2 %). Significant associations between 'trajectory' groups and 'isolation' groups, and between family and child characteristics and 'isolation' groups were identified using Pearson's chi-square ($p < .05$).

3. Results

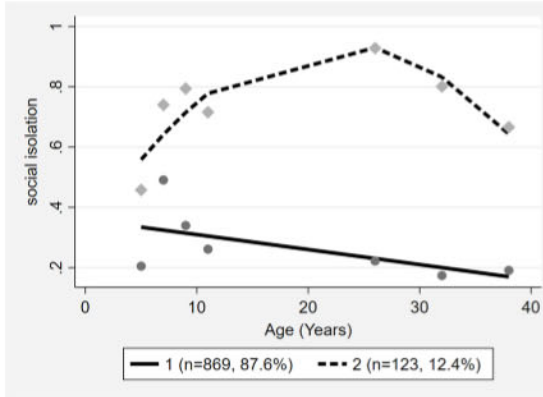
The results of group-based trajectory modelling show substantially improved fit for a three-class model compared to a two-class model (change in BIC = 105.54), and for a four-class model compared to a three-class model (change in BIC = 66.02), and slightly improved fit for the addition of a fifth class (change in BIC = 6.75) and then a sixth class (change in BIC = 5.78) (Fig. 1). Entropy dropped slightly with the addition of each additional class but remained high even for the six-class model (0.84). Inspection of the model classes reveals distinct trajectories up to the four-class model (which shows low isolation, high isolation, increasing isolation, and decreasing isolation groups), while the five-class model further splits the decreasing trajectory into two smaller groups (decreasing early and decreasing late groups), and the six-class model also splits the increasing group into two smaller groups (increasing early and increasing late groups). On this basis, we considered the four-class model to be the most appropriate. We labelled the identified trajectory groups as: 'never' (group 3 in Fig. 1c, 71.6 %); 'adult only' (group 1, 10.1 %); 'child only' (group 2, 14.3 %); and 'child & adult' (group 4, 4.0 %). Descriptive statistics for the four-class model are shown in Table 1.

Family characteristics for the four 'trajectory' groups are shown in Table 2. Each of the three groups experiencing any degree of isolation were born to teen-aged mothers in a higher proportion (with a gradient ranging from 10.1 %, through 15.5 %, to 25.6 %) than the 'never isolated' group (7.9 %). The 'adult' groups ('adult only' at 17.7 %, 'adult and child' at 25.0 %) – were also more likely to have been raised in a single-parent family than the 'never isolated' group (12.6 %). There was a gradient to the proportion experiencing three or more changes in residence during childhood, with the 'never isolated' group the lowest at 29.4 %, 'adult only' at 39.0 %, 'child only' at 38.0 %, ranging up to the 'child and adult' group at 47.5 %. The proportion of participants deemed to have experienced 'probable or severe' maltreatment also increased monotonically: 'never isolated' at 33.2 %, 'adult only' at 34.0 %, 'child only' at 49.3 %, and 'child and adult' at a high peak of 60.0 %. Two of the family factors – socio-economic status, and the quality of family relationships – were not associated with group membership. In general, across the ordered 'trajectory' groups, there was an increasing proportion in the high-risk category of each family factor, with around double the size in the 'child and adult' group compared to the 'never isolated' group. Family risk factors for child onset were clearly also risk factors for adult onset and the persistence of isolation. An exception to these general patterns was having a single parent during childhood where – although there was a significant association with 'trajectory' group membership – there was not a linear risk gradient, i.e. adult-onset isolation was related to a higher proportion from a single-parent family than was child-onset isolation.

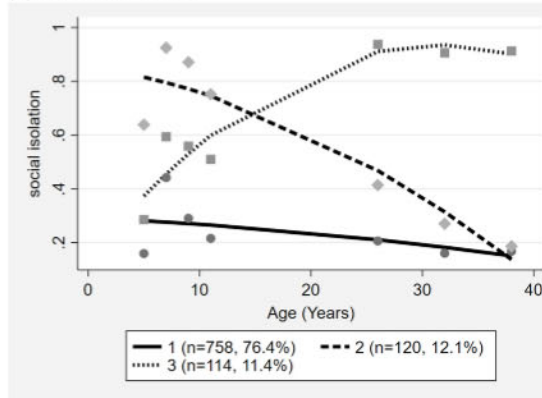
'Trajectory' group membership did not differ by sex of the child (χ^2 (3, $N = 992$) = 5.60, $p = .133$). Child characteristics for each 'trajectory' group are described in Table 1. Across groups, there was an increasing proportion in the highest-risk category (quintile 5) for low self-control (ranging from 15.2 % to 57.5 %) and high worry/fearfulness (ranging from 15.2 % to 50.0 %); for both outcomes, the proportion in the

Classes	BIC	Entropy
1	-3487.94	1
2	-3222.85	0.952
3	-3117.31	0.911
4	-3051.29	0.890
5	-3044.54	0.869
6	-3038.76	0.836

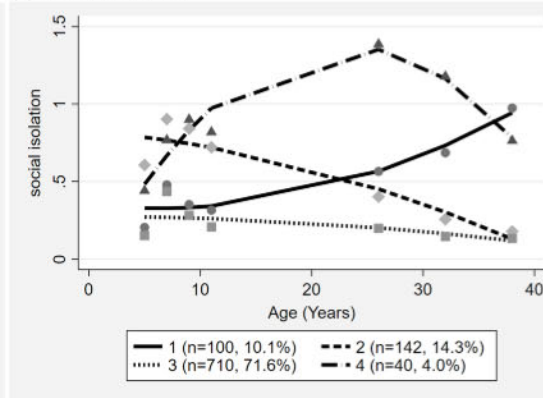
(a) Two-class model



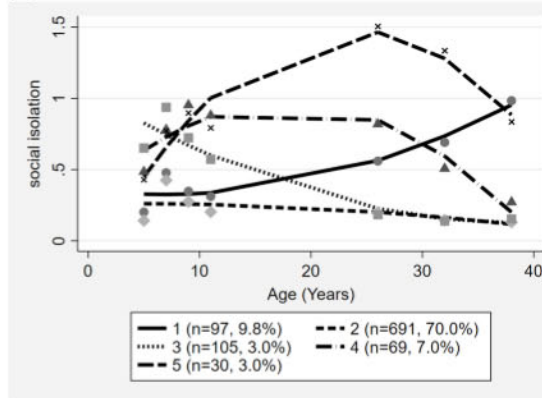
(b) Three-class model



(c) Four-class model



(d) Five-class model



(e) Six-class model

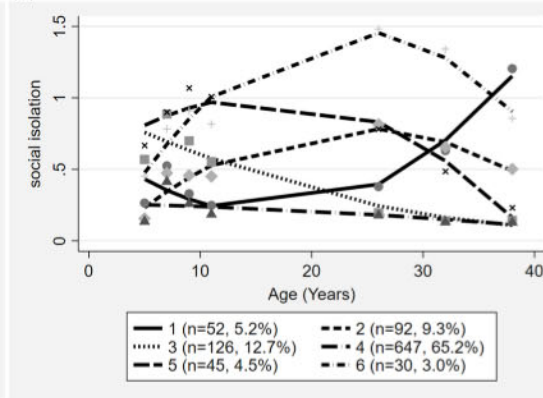


Fig. 1. Plots for group-based trajectory modelling of social isolation scores (range 0-2) from ages 5-38 ($n=992$), using two, three, four, five and six classes. Dots represent mean social isolation scores for each trajectory at each age. Fit statistics are shown preceding the plots. The Bayesian Information Criterion (BIC) balances complexity and goodness of fit, with values closer to zero indicating a better fit. Entropy represents the mean classification accuracy (i.e., the mean posterior probability of assignment into classes), with values closer to 1 indicating greater accuracy.

highest-risk category was around four times greater in the ‘child and adult’ group than in the ‘never isolated’ group. *Child-behavioral* risk factors tended to be specific to child isolation, though the adult-onset group showed proportions in the highest-risk categories that occupied an intermediate level on the spectrum, elevated above those for the ‘never isolated’ group.

We see a general pattern of relationships between each domain of risk factors and the onset and/or persistence of social isolation. Being in the high-risk category for family factors tended to impact on both child and adult onset of isolation. Increased child-behavioral risks applied more to the child onset of isolation. Risk factors conferring persistence of

isolation (i.e. continuation from childhood) were spread across both domains.

Sensitivity analyses using ‘isolation’ groupings based on top 15 % cut-offs in childhood and adulthood produced similar findings. ‘Trajectory’ group membership was very similar to ‘isolation’ group membership ($\kappa = .594, p < .0001$) (Tables 3 and 4). Associations with family and child behavioural risk factors were replicated using ‘isolation’ groups (Table 5).

Table 1
Descriptive statistics for trajectory groups (4-class model).

Group	Mean (SEM) Social Isolation scores							Coefficients (95 % CI), x 1000	
	5	7	9	11	26	32	38	Linear	Quadratic
Never isolated (n = 710)	0.15 (0.01)	0.44 (0.02)	0.28 (0.01)	0.21 (0.01)	0.20 (0.01)	0.14 (0.01)	0.13 (0.01)	-5.52 (-20.14 - 9.10)	-0.33 (-0.66 - 0.00)
Adult only (n = 100)	0.18 (0.03)	0.48 (0.04)	0.35 (0.04)	0.33 (0.04)	0.57 (0.04)	0.73 (0.05)	1.03 (0.04)	-7.61 (-28.72 - 13.50)	0.61 (0.10-1.12)
Child only (n = 142)	0.67 (0.04)	0.93 (0.04)	0.89 (0.03)	0.77 (0.04)	0.43 (0.04)	0.28 (0.03)	0.19 (0.03)	0.12 (-5.49 - 5.73)	-0.11 (-0.25 - 0.03)
Child & adult (n = 40)	0.45 (0.07)	0.78 (0.07)	0.93 (0.08)	0.81 (0.08)	1.46 (0.08)	1.23 (0.09)	0.80 (0.08)	124.79 (96.74-152.84)	-2.69 (-3.34 - -2.04)

Stata code: traj if nmis < 4, var(socisol_5-socisol_38) indep(a1-a8) model(cnorm) min(-1) max(3) order(2 2 2 2).

Table 2
Characteristics of ‘trajectory’ groups by domain.

Characteristics: Domain & factors	Trajectory group				Test of difference between groups	
	Never isolated	Adult Only	Child only	Child & adult	X ²	p
Family environment						
Socio-economic status (%)	(n = 707)	(n = 100)	(n = 141)	(n = 39)	11.15	0.084
Low	18.4	26.0	28.4	20.5		
Medium	65.1	56.0	58.9	69.2		
High	16.6	18.0	12.8	10.3		
Teen-aged mother	(n = 708)	(n = 99)	(n = 142)	(n = 39)	18.93	0.0001 *
Yes	7.9	10.1	15.5	25.6		
Single parent for at least a year, up to age 11 (%)	(n = 706)	(n = 96)	(n = 138)	(n = 39)	21.81	<0.0001 *
Yes	12.6	17.7	12.3	25.0		
Change in residence (%)	(n = 710)	(n = 100)	(n = 142)	(n = 40)	22.88	0.006 *
(Number) 0	30.4	26.0	26.1	22.5		
1	23.8	16.0	25.4	5.0		
2	16.3	19.0	10.6	25.0		
3+	29.4	39.0	38.0	47.5		
MOOS family relations index at age 9	(n = 637)	(n = 84)	(n = 129)	(n = 31)	21.24	0.047
Quintile 1	19.2	19.1	31.8	35.5		
2	15.5	20.2	17.1	19.4		
3	22.3	20.2	21.7	25.8		
4	24.2	21.4	17.1	12.9		
(high) 5	18.8	19.1	12.4	6.5		
Maltreatment (%)	(n = 710)	(n = 100)	(n = 142)	(n = 40)	23.02	<0.0001 *
Probable/severe	33.2	34.0	49.3	60.0		
Child behavior	(n = 710)	(n = 100)	(n = 142)	(n = 40)		
Self-control (%)					82.79	<0.0001 *
Quintile 1	22.3	16.0	8.5	5.0		
2	22.5	17.0	14.8	7.5		
3	20.3	30.0	18.3	12.5		
4	19.7	21.0	25.4	17.5		
(low) 5	15.2	16.0	33.1	57.5		
Worry/fearfulness (%)					126.97	<0.0001 *
Quintile 1	18.0	4.0	2.1	0.0		
2	26.3	17.0	11.3	12.5		
3	19.7	22.0	14.1	7.5		
4	20.7	29.0	27.5	30.0		
(high) 5	15.2	28.0	45.1	50.0		

* p < .05.

Table 3
‘Social isolation’ groups - defined by presence in child and adult (both informant-reported).

Isolated child	Isolated adult (n = 951)	
	No (83.8 %)	Yes (16.2 %)
No (85.2 %)	Never (n = 705, 74.1 %)	Adult only (n = 109, 11.5 %)
Yes (14.8 %)	Child only (n = 92, 9.7 %)	Child & adult (n = 45, 4.7 %)

$\chi^2 (1, N = 951) = 32.71, p < .0001.$

Table 4
‘Trajectory’ groups (4-class model) - distribution by isolation status.

Trajectory group:	Never isolated	Adult only	Child only	Child & adult	Total
Isolation status:					
Never	89.4 %	1.7 %	8.9 %	0%	n = 699 (74.1 %)
Adult only	11.0 %	67.0 %	6.4 %	15.6 %	n = 109 (11.6 %)
Child only	36.3 %	3.3 %	60.4 %	0 %	n = 91 (9.7 %)
Child & adult	4.6 %	25.0 %	25.0 %	45.5 %	n = 44 (4.7 %)
Total	n = 672 (71.3 %)	n = 99 (10.5 %)	n = 135 (14.3 %)	n = 37 (3.9 %)	n = 943

$\kappa = .594 (SE 0.022), p < .0001.$

4. Discussion

This paper presented the results of a longitudinal study of social isolation from a New Zealand birth cohort followed to mid-adulthood. Social isolation was measured via informant report for each individual in childhood (ages 5–11) and again in adulthood (ages 26–38). Using group-based trajectory modelling, we identified four trajectory groups which mapped well to the onset and persistence of social isolation: ‘never isolated’, ‘adult only’, ‘child only’, and ‘child and adult’. We then proceeded to characterize these four trajectory groups according to significant risk factors for social isolation.

Our findings add to the literature by describing the social isolation transitions across the life course, and by identifying the factors that contribute to typical patterns that point the way to where interventions might be aimed. We now return to each of our research questions and discuss the findings and implications.

1 Do socially isolated children become isolated adults, or are there distinct ‘child-onset’ and ‘adult-onset’ groups?

Our study shows a robust association between social isolation measured at each of the two life stages. However, it was uncommon for

Table 5
Characteristics of ‘social isolation’ groups by domain.

Characteristics: Domain & factors	Isolation group				Test of difference between groups	
	Never isolated	Adult only	Child only	Child & adult	X ²	p
Family environment						
Socio-economic status (%)	(n = 703)	(n = 109)	(n = 91)	(n = 45)	14.78	0.022 *
Low	18.4	22.0	26.4	35.6		
Medium	65.9	64.2	51.7	48.9		
High	15.8	13.8	22.0	15.6		
Teen-aged mother	(n = 703)	(n = 107)	(n = 92)	(n = 45)	7.11	0.068
Yes	8.5	13.1	15.2	15.6		
Single parent for at least a year, up to age 11 (%)	(n = 699)	(n = 105)	(n = 91)	(n = 44)	24.54	<0.0001 *
Yes	10.9	26.7	14.3	25.0		
Change in residence (%)	(n = 705)	(n = 109)	(n = 92)	(n = 45)	31.35	0.0003 *
(Number) 0	30.6	29.4	26.1	20.0		
1	25.3	12.8	15.2	13.3		
2	24.4	31.2	23.9	24.4		
3+	19.7	26.6	34.8	42.2		
MOOS family relations index at age 9	(n = 634)	(n = 91)	(n=74)	(n=37)	16.90	0.153
Quintile 1	20.0	19.8	27.0	35.1		
2	15.3	26.4	17.6	8.1		
3	22.2	22.0	21.6	21.6		
4	23.3	19.8	16.2	18.9		
(high) 5	19.1	12.0	17.6	16.2		
Maltreatment (%)	(n = 705)	(n = 109)	(n = 92)	(n = 45)	27.23	<0.0001 *
Probable/severe	32.1	40.4	52.2	60.0		
Child behavior						
Self-control (%)	(n = 705)	(n = 109)	(n = 92)	(n = 45)	88.72	<0.0001 *
Quintile 1	22.8	14.7	4.4	8.9		
2	23.3	15.6	12.0	6.7		
3	19.9	31.2	18.5	11.1		
4	19.7	19.3	25.0	26.7		
(low) 5	14.3	19.3	40.2	46.7		
Worry/fearfulness (%)					115.36	<0.0001 *
Quintile 1	18.3	5.5	0	2.2		
2	25.8	18.4	12.0	4.4		
3	19.0	22.9	15.2	8.9		
4	20.9	25.7	27.2	26.7		
(high) 5	16.0	27.5	45.7	57.8		

* p < .05.

isolated children to become isolated adults (fewer than 1/4 did: 4.0 % of 18.3 % [= 4.0 % + 14.3 %]). Similarly, only a minority of isolated adults were isolated as children (fewer than 1/3: 4.0 % of 14.1 % [= 4.0 % + 10.1 %]). This suggests that there is considerable resilience or capability to recover from social isolation in childhood, and that, with further understanding, interventions to strengthen this capability may be possible. For example, a Finnish longitudinal study of children found that having friends acted as a buffer against the occurrence of adjustment problems, a harmful effect of social isolation (Laursen et al., 2007).

2 What factors characterize these ‘trajectory’ groups that represent different patterns of social isolation experienced by children as they become adults?

There was no significant difference across our trajectory groups by sex, which accords with another study that found similar patterns of social withdrawal in both boys and girls (Schneider et al., 2000). In general, across family-environment and child-behavior risk factors, the ‘child and adult’ group (where isolation persisted) was over-represented in the high-risk categories compared to the ‘never isolated’ group, with ‘child only’ and ‘adult only’ groups occupying an intermediate position between these two extremes. Thus, where our ordered isolation types are concerned, there does appear to be a gradient of risk related to the degree of disadvantage, especially for these factors that have been previously linked to social isolation: residential stability (Waldfoegel et al., 2010), and maltreatment (Elliott et al., 2005) (all in the family domain), and child self-control (Maszk et al., 1999) and anxiety and depression (Matthews et al., 2015). This novel finding of a risk gradient points to potential interventions that would seek to reduce disadvantage

across the board and so ameliorate social isolation across all groups but with the most disadvantaged group benefitting the most (Graham, 2004). Furthermore, in general, being in the high-risk categories for significant factors in the family domain was predictive of both child and adult onset, while factors in the child domain tended to predict child onset of social isolation; factors from both domains were predictive of persistence from childhood to adulthood. This finding reiterates the primary importance of the family environment as a determinant of human development with effects on the state of the child and continuing to the adult (Bronfenbrenner, 1986). Family difficulties and disadvantage pose multiple risks to children in the forms of, for example: (i) physical abuse and neglect, (ii) stresses on immature biological systems, (iii) poor socialisation and transmission of social skills, and (iv) the shaping of unhealthy behaviors (Repetti et al., 2002). In the ‘child and adult’ group, relative to the other groups, there were particularly high levels of maltreatment (60.0 %), low child self-control (57.5 %), and high child worry/fearfulness (55.0 %). This is in line with the finding of Matthews et al. (2015) that school-age children who had been physically maltreated or who had mental health difficulties were at greater risk of being socially isolated. While we cannot conclude that these associations are causal, our findings may indicate, in particular, that reducing maltreatment (in the family) and child worry/fearfulness, and improving child self-control are possible mechanisms to preventing the persistence of isolation into adulthood. Long-term follow up of intervention studies focusing on maltreatment and child behavior may elucidate this further.

Sensitivity analyses showed that a four-group trajectory model more or less defined the same groups as using empirical criteria, i.e. the ‘trajectory’ and ‘isolation’ groups corresponded well. The family and

child characteristics of the four groups were very similar in both formulations. These findings provide confidence that the four-group typology is realistic and has heuristic value.

In general, our findings confirm that socially isolated adults tend to come from disadvantaged family backgrounds, and have more behavioral and emotional difficulties. Additionally, we identify four distinct groups on the basis of the onset and persistence of social isolation at two life stages. The theoretical significance of this study lies in its focus on the development of social isolation across the life course, and the family and child factors involved in the mechanism (de Jong Gierveld et al., 2016d). In policy terms, understanding the factors associated with the onset and persistence of social isolation allows the formulation of guidelines for its prevention, and the design of treatment options. Providing early support for families and children is crucial to preventing the onset and to interrupting the persistence of social isolation. This study goes further in enabling the specification of interventions to suit individuals experiencing social isolation at different life stages, and in identifying vulnerable groups that may require more assistance from health and social services.

4.1. Strengths and limitations

The main strength of this study is the longitudinal information on social isolation measured from childhood to adulthood. This enables not only the analysis of onset but also of any persistence across the life course. Both child and adult isolation measures were matched on being informant-reported and multi-wave: the first (for the child) was taken from parent and teacher reports at ages 5, 7, 9 and 11 while the second (for the adult) was taken from reports by close acquaintances at ages 26, 32 and 38. Using our child and adult measures to form four types, we were able to identify a wide range of family and child factors across multiple domains that were significantly associated with these types.

We chose one specific form of finite mixture modelling, group-based trajectory modelling, so as to group individuals who most closely follow the same trajectory – that is, to minimize variability within trajectory groups (Nagin and Odgers, 2010). Group-based trajectory modelling does not permit between- and within-subjects variability, unlike other approaches such as latent class growth analysis (which permits within-subjects variability over time) and growth mixture modelling (which permits both) (van der Nest, 2020). Using group-based trajectory modelling we found BIC continued to improve with the addition of classes, suggesting our approach may not have captured all the variability in the data.

In profiling our types, an assumption is that the characteristics described are risk factors preceding or contemporaneous with social isolation. We cannot infer causality and we have not accounted for confounding by other factors. The childhood factors seem more relevant for social isolation that originated in childhood, but less so for adult-onset isolation. Therefore, while these early risk factors are important, it is also necessary to acknowledge that other risk factors will be bound to emerge in later developmental periods (e.g. job loss, moving to a new town, death of a spouse) which could be more germane than childhood experiences for the onset and persistence of social isolation in adults.

Another limitation involves our measure of social isolation. Just two items were assessed, which were not designed specifically to measure social isolation and only cover one aspect of social isolation, i.e. social disconnectedness (Cornwell and Waite, 2009), and did not assess whether subjects perceived the disconnectedness negatively or had an emotional response to it. Further, although we had child and adult measures of social isolation, we did not have a measure of isolation in adolescence, a critical life stage for development and an important formative period for adulthood. Finally, the findings derive from analyses of a New Zealand cohort so may not be generalizable to all populations.

4.2. Future research

This paper examines risk factor levels for groupings by social isolation that have an embedded longitudinal component. More sophisticated longitudinal analyses – with the requisite data – offer the possibility of assessing changes in risk factors in tandem with changes in social isolation (Piccarreta and Studer, 2019). Inflection points during the life course – perhaps indicating critical periods – could thus be identified where interventions could reasonably be targeted to good effect. Taking into account later circumstances that might be more relevant to adulthood would better characterize our groupings and add to explanation of onset and persistence.

4.3. Conclusion

This study formed groups of social isolation based on group-based trajectory modelling, and then characterized each group according to risk factors previously implicated in social isolation. There was a robust but moderate association between social isolation measured in childhood and adulthood, but fewer than one-quarter of isolated children became isolated adults. Points of intervention are suggested by our findings: both family- and child-based interventions to address child onset and persistence into adulthood. We have less to say about tackling adult onset as a separate concern – although family environment was important – since the risk factors we consider were measured at the family and child levels rather than at the time of adulthood. Nevertheless, our research provides insights into the development of social isolation and potential intervention points during the life course.

Declaration of Competing Interest

The authors report no declarations of interest.

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The datasets reported in the current article are not publicly available due to lack of informed consent and ethical approval, but are available on request by qualified scientists. Requests require a concept paper describing the purpose of data access, ethical approval at the applicant's university, and provision for secure data access. All data analysis scripts and results files are available for review.

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