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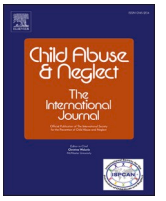

Adverse childhood experiences and trajectories of multimorbidity in individuals aged over 50: Evidence from the English Longitudinal Study of Ageing

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ABSTRACT

Background: Adverse childhood experiences (ACE) are important for chronic diseases yet their association with multimorbidity remains understudied. Few studies consider the complexity of multimorbidity or observe multimorbidity development over time.
Objective: We investigated whether ACE were associated with multimorbidity at baseline and over a 12-year follow-up period.
Participants and setting: 5326 participants aged over 50 were obtained from the English Longitudinal Study of Ageing (ELSA).
Methods: An ACE summary score was derived using eight ACE items measuring abuse, social care, and household dysfunction. From repeated measurements of 29 chronic conditions over a 12-year period (2008–2019) we derived two multimorbidity measures: number of chronic diseases and number of chronic disease categories. We used multinomial logistic regression to assess associations between ACE and both measures. Mixed effects models were estimated to examine trajectories of multimorbidity by ACE over time.
Results: Graded associations between ACE and multimorbidity were observed. Compared to those without ACE, participants with ≥3 ACE had three times the risk of having ≥3 chronic diseases (RRR 3.06, 95 % CI 1.85–5.05) and falling into ≥3 chronic disease categories (RRR 2·93 95 % CI 1·74–4·95). Graded associations persisted during 12-year follow-up, though differences in multimorbidity between those with ≥3 ACE and those without ACE remained constant (B 0.02, 95 % CI 0·01–0·03, and B −0·01, 95 % CI −0·02–0·00, number of chronic conditions and chronic condition categories respectively).
Conclusion: ACE are associated with multimorbidity risk and complexity, associations arising before the age of 50. Early intervention amongst those with ACE could attenuate this association.

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1. Introduction

Adverse childhood experience (ACE) is a term pertaining to adverse or traumatic events during childhood (Kalmakis & Chandler, 2014; O'Shea et al., 2021). These usually include experiences of abuse, household dysfunction, residential care, and victimization (Demakakos et al., 2020). Acting as a potent chronic stressor, ACE affect the mind and body during critical periods of development resulting in lifelong impacts (Gunnar & Quevedo, 2007; Mohler-Kuo et al., 2019; Shonkoff et al., 2012). Profound effects on stress reactivity and regulation are observed in children and adults with the high ACE exposure (Gunnar & Quevedo, 2007). Additionally, individuals with ACE are more likely to engage in health-risk behaviours, including during susceptible times in their development such as adolescence (Anda et al., 1999; Demakakos & Steptoe, 2022; Gilbert et al., 2009; Hughes et al., 2017; Kalmakis & Chandler, 2015; Konkolÿ Thege et al., 2017; Petruccelli et al., 2019; Wiss & Brewerton, 2020).

Multimorbidity, defined as the coexistence of multiple chronic conditions, is a growing population health challenge (Fortin et al., 2012; Uijen & van de Lisdonk, 2008). As the population gets older, the prevalence of long-term conditions is increasing and multimorbidity is now the norm (Academy of Medical Sciences, 2018; Uijen & van de Lisdonk, 2008). Over half of those aged 65 to 74 are multimorbid, this proportion increasing to 83·2 % in those aged over 85 (Cassell et al., 2018). Despite the high prevalence of multimorbidity, healthcare services are not designed to meet the associated challenges (Hughes et al., 2013). Most consultations in primary care involve patients with multimorbidity, but guidelines are generally designed for single conditions (Hughes et al., 2013). In relation to multimorbidity, healthcare appears to be fragmented and poorly coordinated. This results in an increased risk of polypharmacy and high treatment burden in terms of self-management of the conditions and attendance of multiple appointments (Wallace et al., 2015). Ideally, effectively managing multimorbid patients requires a structured care plan to alleviate these issues (Lee et al., 2015). This has serious impacts on disease management with the associated healthcare costs being high (Academy of Medical Sciences, 2018; Lee et al., 2015; Salisbury et al., 2011; Vetrano et al., 2019; Zulman et al., 2015). Multimorbid patients also experience poorer health outcomes such as increased disability and reduced well-being and quality of life (Barnett et al., 2012; Marengoni et al., 2011; McDaid et al., 2013; Nguyen et al., 2019, 2021; Nunes et al., 2016; Ryan et al., 2015; Vetrano et al., 2018). Therefore, multimorbidity presents a growing challenge to the healthcare system and the population.

ACE are associated with a lower quality of life and numerous chronic conditions across multiple bodily systems (Demakakos et al., 2022; Demakakos & Steptoe, 2022; Kalmakis & Chandler, 2015; Petruccelli et al., 2019). Prior studies found ACE are associated with an increased prevalence of multimorbidity, (Atkinson et al., 2021;England-Mason et al., 2018 ; Henchoz et al., 2019 ; Lin et al., 2021 ; Sinnott et al., 2015 ; Tomasdottir et al., 2015 ; Yang et al., 2020) with some observing a dose response relationship (Atkinson et al., 2021; England-Mason et al., 2018; Lin et al., 2021; Sinnott et al., 2015). Most define multimorbidity as two or more chronic conditions (England-Mason et al., 2018; Henchoz et al., 2019; Lin et al., 2021; Sinnott et al., 2015; Tomasdottir et al., 2015; Yang et al., 2020). However, this definition of multimorbidity is crude and lacks the specificity needed to classify individuals according to their health needs. The more complex an individual's multimorbidity, the more dramatic a health decline they are expected to undergo (Nguyen et al., 2021). Complex multimorbidity has been defined as 'the co-occurrence of three or more chronic conditions affecting three or more different body systems within one person' (Harrison et al., 2014). Within an older population, examining both the number of conditions and number of different disease categories affected enables better identification of high-need individuals. Moreover, despite evidence of an association between ACE and presence of multimorbidity in later life, few studies have examined the trajectories of multimorbidity and their evolution over time. An earlier study found higher rates of growth in multimorbidity in association with parental physical abuse, poor parental mental health, and inadequate provision of food. Those who had these experiences developed health conditions more quickly than those without them, thus developed multimorbidity at an earlier time point (Yang et al., 2020). Two further studies found that those with higher ACE had a faster rate of multimorbidity development (Chandrasekar et al., 2023; Zheng et al., 2022). However, both studies defined multimorbidity through a simple count of conditions.

Our study aims to cover these gaps in our knowledge of the association between ACE and multimorbidity. We studied whether a summary ACE score was associated with multimorbidity. To identify those who are most impacted by multimorbidity and assess multimorbidity complexity we considered number of chronic conditions and number of chronic disease categories. Further, we investigated the association between summary ACE score and trajectories of multimorbidity over a 12-year period (2008–2019).

Given the high financial, societal and the individual costs of multimorbidity, our main aim is to contribute evidence that will help to better understand the life course dimension of multimorbidity and the significance of childhood exposures for multimorbidity later in life. This evidence can inform prevention strategies, policymaking as well as clinical practice and potentially contribute to the effort to reduce the burden of multimorbidity.

2. Methods

2.1. Study population

We used data from the English Longitudinal Study of Ageing (ELSA) (www.elsa-project.ac.uk), a panel study of English adults aged ≥50. The baseline interview (wave one) took place in 2002–2003 and comprised a nationally representative sample of 11,391 individuals. Participants were interviewed every two years and had a health examination every four years. Childhood adversity data was collected at the 2007 ELSA Life History Interview. The one-off study followed wave three and collected retrospective information about the lives of participants prior to joining ELSA. We restricted the sample to core ELSA members who had completed the life history interview and incorporated ACE questionnaire and had wave 4 multimorbidity data available.

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2.2. Measurement of adverse childhood experience

We used eight binary ACE variables (yes-no) that measured the following ACE: (1) lived most of childhood in a single biological mother family, (2) lived most of childhood in social care settings (e.g. in children's home or with foster parents), (3) separation from mother for more than six months, (4) victim of serious physical attack/assault at age ≤16 years, (5) victim of sexual assault including harassment at age ≤16 years, (6) physically abusive parents, (7) parents with substance abuse or mental health problems and (8) parents argued or fought very often. Unless otherwise stated, all measures refer to adversities that occurred at age <16 years and cover core domains of psychosocial adversity including abuse, family disorganisation and social care experiences. An ACE summary score was generated by adding these variables then categorising as follows: 0,1,2, ≥3. To avoid unnecessary exclusion of participants with few missing values, it was assumed that participants with missing ACE variables did not experience this ACE. 365 observations were re-coded in this manner.

2.3. Measurement of multimorbidity

We used repeated measurements of 29 self-reported doctor-diagnosed chronic diseases. Based on the previous work, we derived a simple multimorbidity index, a chronic disease count based on the following 19 common conditions: 1) heart attack, 2) stroke, 3) congestive heart failure, 4) heart murmur, 5) heart arrhythmia, 6) angina, 7) hypertension, 8) diabetes mellitus, 9) (any) cancer (excl. minor skin cancers), 10) (any) arthritis, 11) osteoporosis, 12) dementia (incl. Alzheimer's disease), 13) Parkinson's disease, 14) depression, 15) anxiety, 16) (any) psychiatric condition other than anxiety or depression, 17) eye condition (any of the following: cataract, glaucoma, diabetic eye, macular degeneration), 18) asthma and 19) chronic lung disease (incl. chronic obstructive pulmonary disease) (Diederichs et al., 2011). A continuous score was generated based on the count of chronic conditions and a categorical variable generated and grouped as follows: 0,1,2, ≥3.

A secondary multimorbidity measure was derived, based on the concept of complex multimorbidity (Harrison et al., 2014; Singer et al., 2019). It counts how many disease categories an individual falls into based on their chronic conditions, categorised as per Table 1. As above, both a continuous and categorical variable were created. The categorical variable was grouped as follows: 0,1,2, ≥3.

2.4. Covariates

Models were adjusted for age, sex (self-reported as male or female), and childhood socioeconomic position (SEP) (paternal or main carers' occupational class at age 14 and number of books in the home at age 10 years). Adult SEP may be on the pathway between ACE and multimorbidity, so we considered highest educational attainment and total net household wealth in wave 4.

2.5. Statistical analysis

First, we examined the bivariate associations between ACE, covariates, and outcomes (Table 2). We used multinomial logistic regression to examine the association between the categorised summary ACE score and number of chronic conditions at baseline (Table 3, Suppl. Table 1). For each association, relative risk ratios were calculated. Initially, models were adjusted for age and sex. We additionally adjusted for childhood SEP, then education and wealth. The same analytical approach was used when examining chronic disease categories (Table 3, Suppl. Table 2).

To examine how multimorbidity associated with ACE changes over time, multinomial regression of wave nine multimorbidity was also carried out. The analysis was conducted twice, regressing the categorical variable of each multimorbidity measure. To deal with attrition, not present at wave nine was included as an outcome. Covariates were adjusted for as previously stated (Table 4, Suppl. Tables 3 and 4).

Linear mixed effects models were generated to predict the number of chronic conditions an individual had at waves four to nine.

Table 1
Categorisation of chronic conditions into disease categories.

Disease categories	Chronic Conditions included
Circulatory	Heart attack/myocardial infarction, stroke, congestive heart failure, heart murmur, heart arrhythmia, angina, hypertension, or any other cardiovascular disease
Endocrine	Diabetes mellitus
Cancer	Any cancer excluding minor skin cancers
Musculoskeletal	Arthritis (any) or osteoporosis
Mental Health/ Psychiatric	Anxiety, depression, manic depression, emotional problems, mood swings, psychosis, schizophrenia, other psychiatric condition, or hallucinations
Neurological	Dementia, Alzheimer's disease, or Parkinson's disease
Eye Condition	Cataract, glaucoma, diabetic eye, macular degeneration
Respiratory	Asthma or chronic lung disease (incl. chronic obstructive pulmonary disease)

Table 2
Variables cross tabulated by ACE category. *Missing variable not included in x^2 testing.

Covariate	Number of ACE's categorised				*P*-value
	0	1	2	3+	
	(*N* = 3301)	(*N* = 1417)	(*N* = 424)	(*N* = 184)	
Sex, N (%)					0·039
Male	1499 (45·41)	614 (43·33)	165 (38·92)	74 (40·22)	
Female	1802 (54·59)	803 (56·67)	259 (61·08)	110 (59·78)	
Age category, N (%)					<0·001
51–64	1590 (48·17)	640 (45·17)	222 (52·36)	123 (66·85)	
65–79	1309 (39·65)	626 (44·18)	167 (39·39)	58 (31·52)	
80+	402 (12·18)	151 (10·66)	35 (8·25)	3 (1·63)	
Paternal or main carer's occupation at age 14 years, N (%)					<0·001
Managerial, professional, business owner, administration	1137 (34·44)	424 (29·92)	120 (28·30)	44 (23·91)	
Sales, trade, and care professions	1063 (32·20)	425 (29·99)	132 (31·13)	52 (28·26)	
Plant worker, casual jobs, unemployed & other	999 (30·26)	505 (35·64)	147 (34·67)	72 (39·13)	
All others	102 (3·09)	63 (4·45)	25 (5·90)	16 (8·70)	
Number of books in the home aged 10					<0·001
None or very few (0–10 books)	730 (22·11)	408 (28·79)	133 (31·37)	59 (32·07)	
Enough to fill one shelf (11–25 books)	815 (24·69)	325 (22·94)	99 (23·35)	34 (18·48)	
Enough to fill one bookcase (26–100 books)	1052 (31·87)	376 (26·53)	109 (25·71)	45 (24·46)	
Enough to fill two bookcases (101–200 books)	309 (9·36)	131 (9·24)	32 (7·55)	14 (7·61)	
Enough to fill three or more bookcases (>200 books)	281 (8·51)	103 (7·27)	17 (3·01)	13 (7·07)	
Missing	114 (3·45)	74 (5·22)	34 (8·02)	19 (10·33)	
Education, N (%)					0·066*
Degree/Higher/A-level	1421 (43·05)	566 (39·94)	164 (38·68)	90 (48·91)	
GCSE/O-level/Other qualifications	1042 (31·57)	456 (32·18)	134 (31·60)	47 (25·54)	
No qualifications	838 (25·39)	393 (27·73)	126 (29·72)	47 (25·54)	
Missing	0 (0·00)	2 (0·14)	0 (0·00)	0 (0.00)	
Wealth Tercile, N (%)					<0·001*
Wealthiest tercile	1134 (34·35)	467 (32·96)	135 (31·84)	35 (19·02)	
Intermediate tercile	1152 (34·90)	506 (35·71)	133 (31·37)	55 (29·89)	
Poorest tercile	946 (18·66)	425 (29·99)	153 (36·08)	90 (46·91)	
Missing	69 (2·09)	19 (1·34)	3 (0·71)	4 (2·17)	
Wave 4 - number of chronic conditions, categorised N (%)					<0·001
0	546 (16·54)	202 (14·26)	48 (11·32)	21 (11·41)	
1	776 (23·51)	290 (20·47)	78 (18·40)	33 (17·93)	
2	714 (21·63)	301 (21·24)	92 (21·70)	20 (10·87)	
3+	1265 (38·32)	624 (44·04)	206 (28·58)	110 (59·78)	
Wave 4 - number of disease categories, categorised N (%)					<0·001
0	549 (16·63)	202 (14·26)	50 (11·79)	21 (11·41)	
1	935 (28·32)	379 (26·75)	96 (22·64)	43 (23·37)	
2	888 (26·90)	377 (26·61)	131 (30·90)	45 (24·46)	
3+	929 (28·14)	459 (32·39)	147 (34·67)	75 (40·76)	
Wave 9 - number of chronic conditions, categorised N (%)					<0·001
0	123 (3·73)	40 (2·82)	8 (1·89)	4 (2·17)	
1	277 (8·39)	101 (7·13)	22 (5·19)	14 (7·61)	
2	360 (10·91)	134 (9·46)	41 (9·67)	17 (9·24)	
3+	1120 (33·93)	549 (38·74)	191 (45·05)	84 (45·65)	
Missing	1421 (43·05)	593 (41·85)	162 (38·21)	65 (35·33)	
Wave 9 - number of disease categories, categorised N (%)					<0·001
0	127 (3·85)	41 (2·89)	9 (2·12)	4 (2·17)	
1	327 (9·91)	127 (8·96)	27 (6·37)	16 (8·70)	
2	483 (14·63)	191 (13·48)	63 (14·86)	22 (11·96)	
3+	943 (28·57)	466 (32·89)	163 (38·44)	77 (41·85)	
Missing	1421 (43·05)	592 (41·78)	162 (38·21)	65 (35·33)	

The continuous outcome measure was used, and random intercepts and slopes applied. An ACE summary score by time interaction term was generated to enable variability in slope gradients between ACE categories to be observed. This allowed us to see how total ACE score impacts the rate of development of multimorbidity. Confounders were adjusted for as in multinomial regression analysis. Attrition was dealt with through maximum likelihood estimation. The same approach was applied to predict the number of disease categories an individual fell into over this period (Fig. 1, Suppl. Tables 5 and 6).

We conducted supplementary analyses to examine sample attrition and the associations between multimorbidity and individual ACE measures. These can be found in the online Appendix (Suppl. Tables 7 to 9).

2.6. Role of funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report.

Table 3
Multivariate regression analysis investigating the association between ACE's and number of conditions in wave 4.

		3 Chronic Conditions vs 0 Chronic Conditions			3 Disease Categories vs 0 Disease Categories		
		RRR	CI		RRR	CI	
Adjusted for age and sex	0 ACE	Reference Category			Reference Category		
	1 ACE	1·33	(1·09 to	1·63)	1·33	(1·08 to	1·64)
	2 ACE	2·20	(1·56 to	3·11)	2·08	(1·46 to	2·97)
	3+ ACE	3·63	(2·22 to	5·95)	3·55	(2·12 to	5·92)
Additionally adjusted for childhood SEP	0 ACE	Reference Category			Reference Category		
	1 ACE	1·29	(1·06 to	1·58)	1·29	(1·05 to	1·60)
	2 ACE	2·10	(1·49 to	2·97)	1·99	(1·39 to	2·84)
	3+ ACE	3·41	(2·08 to	5·60)	3·32	(1·98 to	5·57)
Additionally adjusted for education and wealth	0 ACE	Reference Category			Reference Category		
	1 ACE	1·31	(1·07 to	1·61)	1·31	(1·06 to	1·62)
	2 ACE	2·05	(1·45 to	2·91)	1·94	(1·35 to	2·78)
	3+ ACE	3·06	(1·85 to	5·05)	2·93	(1·74 to	4·95)

Table 4
Multivariate analysis of the association between ACE category and number of chronic conditions at wave 9 upon adjustment for wave 4 multimorbidity.

		3 Chronic Conditions vs 0 Chronic Conditions			3 Disease Categories vs 0 Disease categories		
		RRR	CI		RRR	CI	
Adjusted for age & sex	0 ACE	Reference category			Reference category		
	1 ACE	1·21	(0·81 to	1·80)	1·30	(0·87 to	1·94)
	2 ACE	2·03	(0·94 to	4·39)	1·95	(0·93 to	4·08)
	3+ ACE	1·65	(0·55 to	4·89)	2·17	(0·73 to	6·43)
Additionally adjusted for childhood SEP	0 ACE	Reference category			Reference category		
	1 ACE	1·16	(0·78 to	1·75)	1·27	(0·85 to	1·90)
	2 ACE	2·05	(0·94 to	4·45)	1·91	(0·91 to	4·01)
	3+ ACE	1·55	(0·51 to	4·66)	1·96	(0·65 to	5·89)
Additionally adjusted for education and wealth	0 ACE's	Reference category			Reference category		
	1 ACE	1·15	(0·77 to	1·74)	1·27	(0·85 to	1·91)
	2 ACE	1·96	(0·89 to	4·30)	1·84	(0·87 to	3·90)
	3+ ACE	1·32	(0·43 to	4·03)	1·65	(0·54 to	5·01)

3. Results

6331 core study members completed the life history interview. Exclusion of 66 individuals without wave 4 multimorbidity data and 939 who did not the complete the ACE questionnaire resulted in an analytical sample of 5326 individuals.

Individuals with higher ACE's were more likely to be younger and female. They were also of lower education and less wealthy. Negative associations were observed between total ACE score and all measures of SEP. A graded association was observed between ACE and both measures of multimorbidity (Table 2).

At baseline (wave four), participants with ACE had a significantly higher relative risk of having ≥3 chronic conditions compared to those with no ACE. This association was graded with those with ≥3 ACE having three times the risk of having ≥3 chronic conditions in the fully adjusted model (RRR 3·06, 95 % CI 1·85–5·05) compared with the reference category (Table 3). Similarly, in the fully adjusted model, those with ≥3 ACE had nearly three times the risk of having conditions that fall into ≥3 disease categories (RRR 2·93 95 % CI 1·74–4·95) compared to the reference category (Table 3). The full results can be found in supplementary tables 1 and 2.

At wave nine, associations between ACE and multimorbidity are attenuated upon adjustment for wave four multimorbidity (Table 4). Full results can be found in supplementary tables 3 and 4.

In growth curve analysis, a graded association was observed between total ACE score and predicted number of chronic conditions at wave four (Fig. 1, panel A). The same graded association was observed between ACE category and wave four multimorbidity measured through disease categories (Fig. 1, panel B). Total ACE score did not have a large impact on the rate of change of either multimorbidity measure. The magnitude of the association between the ACE by time interaction term and number of chronic conditions was very small (B 0·02, 95 % CI 0·01–0·03) (Suppl. Table 5). The ACE by time interaction term was not associated with the number of disease categories an individual fell into (B −0·01 95 % CI −0·02–0·00) (Suppl. Table 6).

Compared to those not included, our sample was younger, wealthier, and more highly educated. Those not included had slightly higher numbers of chronic conditions and fell into more chronic disease categories (Suppl. Table 7).

Supplementary analysis examining the associations between multimorbidity, and individual ACE measures can be found in the online appendix (Suppl. Tables 8–9). Most individual ACE measures were associated with an increased risk of multimorbidity at wave four. This was consistent across both multimorbidity measures. Having physically abusive parents presented the largest risk (RRR 3·68 95 % CI 2·09–6·49) (Suppl. Table 8).

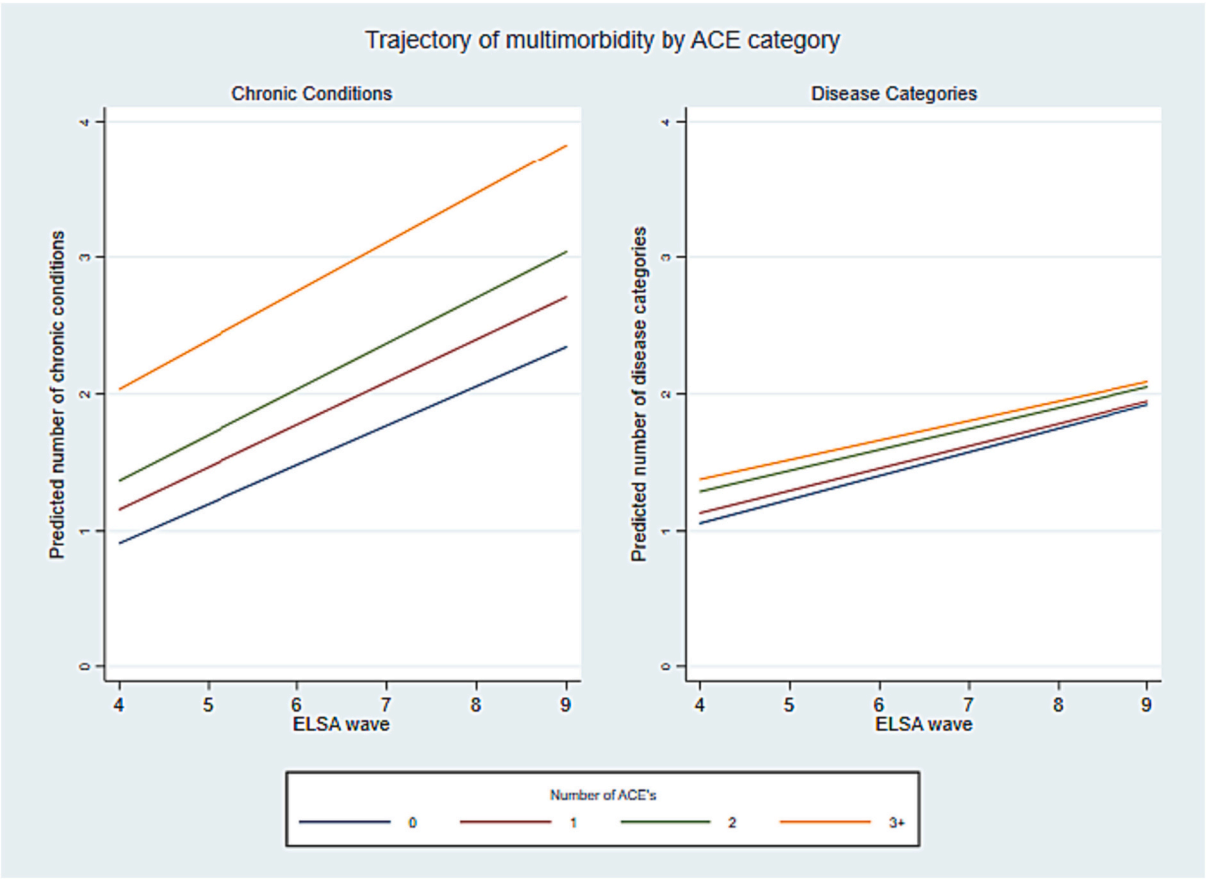

Fig. 1. The trajectory of predicted multimorbidity category by ACE.

4. Discussion

4.1. Key findings

In a national sample of people aged ≥50 years, we found graded associations between multimorbidity and ACE. Those who with ≥3 ACE had nearly three times the risk of having three chronic conditions. Yet the rate at which an individual develops chronic conditions over time in those aged ≥50 years is not associated with total ACE score – an indication that these associations take their final form earlier in the life course. ACE are also associated with more complicated multimorbidity presentations as those with ≥3 ACE had almost three times the risk of having three different chronic disease categories. This demonstrates that, in addition to increasing an individual's risk of multimorbidity, a higher number of ACE are associated with increased multimorbidity complexity.

4.2. Current evidence

Our findings align with prior work which found a graded relationship between ACE and multimorbidity (Lin et al., 2021; Sinnott et al., 2015; Tomasdottir et al., 2015; Yang et al., 2020). One study found that individuals who had any experience of ACE had 1.6 times the odds of developing multimorbidity compared to those who had not (Sinnott et al., 2015). Another study found that those with ≥4 ACE had double the risk of multimorbidity compared with those with none (Lin et al., 2021). In contrast to our work, these studies defined multimorbidity as two or more conditions and were limited compared to our study, which examined in greater detail the complexity of multimorbidity and focused both on chronic disease and chronic disease category count. An earlier study found that those who had experienced four different types of ACE had a higher multimorbidity complexity compared to those who had experienced none. But their definition of multimorbidity was different to ours as it included self-rated health, social isolation, and widespread pain (Hanlon et al., 2020).

We also found that ACE have little impact on the evolution of multimorbidity over a 12-year follow-up period. This finding concurs with those reported earlier by a study of older people in China. They also observed associations between individual ACE measures and multimorbidity at baseline. However, most ACE measures considered were not associated with the rate of change in number of chronic conditions over time (Yang et al., 2020). The presence of graded associations at baseline between ACE measures and multimorbidity

despite the lack of association with the rate of multimorbidity development demonstrates the life course dimension of this association. In contrast, another study did find ACE to accelerate development of multimorbidity in later life (Chandrasekar et al., 2023). However, they did not consider the three ACE most associated wave four multimorbidity within this study - having physically abusive parents, experiences of social care or sexual assault.

4.3. Interpretation of findings

This study aimed to establish whether there was an association between ACE and multimorbidity and to observe its formation over time. Next steps should involve exploration of the putative biological and behavioural pathways behind the association. Given adult SEP partially explains the association, a social pathway is likely to be relevant. There is strong evidence for a link between ACE and health-threatening behaviours. These health-threatening behaviours are heavily socially patterned (Pampel et al., 2010). Higher ACE are associated with smoking, drug and alcohol abuse, physical inactivity, and risky sexual health behaviours (Dong et al., 2003, 2004; Felitti et al., 1998). Unhealthy lifestyles are often adopted as a coping mechanism and can contribute to poor health outcomes (Anda et al., 1999, 2005; Deighton et al., 2018). Those who experience higher ACE are more likely to initiate these behaviours and at an earlier age with detrimental implications for future health and multimorbidity (Rothman et al., 2007).

The associations observed in this study were not fully attenuated upon adjustment for SEP. So, we must consider the potential biomolecular mechanisms linking human experience to disease (Tomasdottir et al., 2015). Numerous pathways are under investigation including immune mechanisms, (Deighton et al., 2018; Ehlert, 2013; Tomasdottir et al., 2015) endocrine stress responses, (Deighton et al., 2018; Ehlert, 2013; Lovallo et al., 2012; Pesonen et al., 2010) epigenetic mechanisms, (Ehlert, 2013; McGowan & Szyf, 2010) and telomere maintenance (Blackburn & Epel, 2012; Needham et al., 2013). ACE have been found to be associated with abnormal cortisol levels, increased inflammation, and reduced immune function (Deighton et al., 2018). The concept of allostasis considers these mechanisms as a whole (Tomasdottir et al., 2015). Allostatic overload describes the link between chronic stress, wide-ranging physiological dysregulation, and disease development (Deighton et al., 2018). It undermines physiological flexibility, resultant changes becoming biologically embedded (Evans, 2003; Mcewen, 2000). Adversity in childhood is a chronic stressor and studies have found it to increase allostatic load (Friedman et al., 2015; Slopen et al., 2014). One study observing that allostatic load mediates the relationship between ACE and multimorbidity (Atkinson et al., 2021). The cumulation of these changes across multiple bodily systems provides a mechanism through which multiple chronic conditions can arise without an apex condition.

Our findings suggest that ACE elicit their impacts throughout childhood and young adulthood and as result, associations are fully developed by the time an individual reaches later life. Therefore, accumulation of chronic conditions is expected to occur at a young age. Previous work has found that younger people with ACE have higher incidence ratios of chronic conditions compared to older people with ACE (Sonu et al., 2019). So, individuals with ACE appear to develop chronic conditions more quickly when they are young, increasing their baseline number of chronic conditions and setting trajectories of multimorbidity into later life.

4.4. Strengths and limitations

The use of data from a nationally representative study makes our findings more generalisable to the older English population. The well-characterised, high-quality nature of ELSA increases the validity of our work, while the strong measurement of socioeconomic status enables an increased understanding of how social disadvantage impacts the associations examined. Our study used a standard set of ACE items, allowing replication of this work in comparable studies.

Individuals included in our sample were younger, more highly educated, and wealthier compared to those not included. They also had a lower prevalence of both multimorbidity measures at wave four. False negatives are likely present within our dataset. To reduce non-response bias, a few missing ACE values were recoded assuming that the individual did not experience this ACE. This may result in an underestimation of the true number of ACE experienced. Additionally, individuals may not want to reveal unpleasant things about themselves. As a result, we assume that our findings likely underestimate the magnitude of the true associations. In addition, those with the highest level of ACE are less likely to present at wave nine. So, trajectory analysis may not reflect the true interaction between ACE and multimorbidity over time amongst those with the highest ACE. To combat this, and to reduce attrition bias, maximum likelihood estimation was used within linear mixed effects models. This ensured optimal use of existing information from all sample members.

Within this study ACE was measured in 2007 and included a select group of variables based on the CDC-Kaiser ACE framework. In recent years, other validated assessments of ACE have collected an expanded range of measures incorporating factors such as bullying, neighbourhood safety, and racial discrimination (Holden et al., 2020). Inclusion of these additional measures more accurately captures ACE, particularly within more racially and socio-economically diverse populations (Cronholm et al., 2015). ELSA has very few non-white participants and so under-counting of ACE due to our choice of metric will be lower than in more diverse populations. However, this lack of diversity also means we cannot investigate the role of ethnicity within this relationship.

The retrospective nature of ELSA's measure of ACE and the self-reporting of chronic conditions may have introduced recall bias. However, our ACE and childhood SEP measures have been used in prior work, showed good predictive variability, and were found to be valid on comparison to prospectively collected data (Jivraj et al., 2020). Additionally, prevalence of multimorbidity in our study at wave four was similar to that previously reported (Barnett et al., 2012; Cassell et al., 2018; Kingston et al., 2018).

5. Conclusions

There is an important life course dimension to the association between ACE and multimorbidity. ACE appear to be a key risk factor in the development of multimorbidity at ages <50 years. Future research should examine the trajectories of multimorbidity and its precursors in relation to ACE in younger populations, considering the role of risk and resilience factors at different stages of the life course. This would enable more effective intervention amongst younger people with ACE, reducing their multimorbidity risk.

Our findings demonstrate that those who have a higher number of ACE are at a higher risk of more complicated multimorbidity. This is significant as individuals with more complicated multimorbidity are predicted to have a steeper health decline, utilise the healthcare system more and require more complex disease management (Barnett et al., 2012; Johnston et al., 2019; Marengoni et al., 2011; McDaid et al., 2013; Nguyen et al., 2021; Sinnott et al., 2015). NICE guidelines state that those with multimorbidity should be identified in primary care and given an individualised treatment plan (National Institute for Health and Care Excellence, 2016, 2017). Given the role of ACE as a risk factor, consideration of ACE within this process may prove timely and useful. Identification of those with ACE in primary care would enable provision of support before an individual's health had declined to a stage where secondary care is required. Trauma-informed services offered early in the life course have been shown to be of value of and so expansion of these services into generalist healthcare environments may be beneficial (Foye et al., 2016; NHS Education for Scotland, 2017).

Finally, work must continue to reduce the number of children experiencing adversity. Given the dose response nature of ACE on multimorbidity, even a small reduction in the number of adversities a child face could reduce their risk of multimorbidity later in life. This would reduce the burden on the individual, their healthcare utilization, and subsequent costs.

CRediT authorship contribution statement

Katherine Taylor: Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Panayotes Demakakos:** Conceptualization, Supervision, Writing – review & editing.

Declaration of competing interest

The authors have no conflicts of interest to declare.

Data availability

The data used in this study are available from the UK Data Service with access codes SN 8688 and 5050.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chiabu.2024.106653.

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