

# BMJ Open Heterogeneous adverse childhood experiences and cognitive function in an elderly Chinese population: a cohort study

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## ABSTRACT

**Objective** To identify the heterogeneity of adverse childhood experiences (ACEs) as well as their association with cognitive function in an elderly Chinese population.

**Design** A retrospective cohort study.

**Participants** The data were from the latest wave of the China Health and Retirement Longitudinal Study and a total of 7222 participants aged  $\geq 60$  were included.

**Primary and secondary outcome measures** Latent class analysis was used to identify the classes characterised by 11 types of ACEs. Cognitive function was measured by the Mini-Mental State Examination (MMSE) and cognitive impairment was defined by education-specific threshold MMSE scores. Logistic models were constructed to examine the relationship between ACE classes and cognitive impairment. Several childhood and adulthood confounding factors were considered.

**Results** Three ACE latent classes were identified. Of them, 76.09% were in the 'Low ACEs' class, 15.43% were in the 'Household dysfunction' class and 8.49% were in the 'Child maltreatment' class. The people in the 'Low ACEs' class seemed to have better childhood family financial situations and higher education levels. The population in the 'Household dysfunction' class tended to live in rural areas and have a higher proportion of men, whereas people in the 'Child maltreatment' class showed a significantly higher proportion of women and higher levels of chronic diseases. 'Child maltreatment' was related to a higher risk of cognitive impairment (OR=1.37, 95% CI: 1.12 to 1.68), while the risk of 'Household dysfunction' was not significantly different from that of the 'Low ACEs' participants (OR=1.06, 95% CI: 0.90 to 1.26).

**Conclusions** The findings supported differences in cognitive function in elderly Chinese people exposed to different types of ACEs.

## INTRODUCTION

Adverse childhood experiences (ACEs) are common, and various studies have reported that the prevalence of ACEs ranged from 25% to 61%.<sup>1 2</sup> ACEs played an important role in determining various health consequences, such as unhealthy behaviour (tobacco usage, alcohol usage and suicide),<sup>3 4</sup> physical health (chronic diseases such as hypertension, diabetes and arthritis)<sup>5 6</sup> and mental

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study explored the heterogeneity of adverse childhood experiences (ACE) classes and their relationship with cognitive function using a nationally representative sample of older Chinese adults.
- ⇒ One limitation was that the ACE values were measured based on a retrospective investigation rather than a prospective cohort. However, we chose to analyse the frequency of ACE occurrences, which may be more valid to measure.
- ⇒ Cognitive impairment defined by the Mini-Mental State Examination, which has a lower sensitivity for mild cognitive impairment, may not efficiently clarify the relationship between ACEs and early cognitive dysfunction.

health (depression and anxiety).<sup>7 8</sup> Studies have also recommended that ACEs affected brain development and cognitive function.<sup>9</sup> Biological evidence has suggested that ACEs may alter the structure of the hippocampus and amygdala, the volume and thickness of the cortical grey matter and the integrity of the white matter tracts in the brain during sensitive periods.<sup>10 11</sup> Impaired development of the brain structure in early life was associated with less efficient memory and executive functions including initiation and non-verbal reasoning.<sup>12 13</sup>

Nevertheless, the relationship between ACEs and cognition was inconsistent between studies. For example, some studies showed that the number of ACEs was not adversely related to later-life cognitive function after adjusting for the covariates,<sup>14 15</sup> whereas other studies reported that ACEs were related to worse cognitive function and faster cognitive decline.<sup>16 17</sup> Other studies indicated that both child maltreatment and childhood stress increased the all-cause risk of dementia in elderly and middle-aged people.<sup>18 19</sup> Other findings suggested that ACEs were associated with cognitive decline or mild cognitive

impairment but did not increase the risk of dementia in an elderly population.<sup>17–20</sup> Furthermore, although the association between ACEs and cognitive function could not be observed when considering ACEs as ACE scores in those studies, the association was observable in some specific adverse events (such as childhood abuse, the death of a parent, bullying or community violence).<sup>16–17–21</sup> Therefore, the type of ACE probably played an important role in the relationship.

However, distinguishing a single independent type of ACE from all adversities is not practically possible. Some research revealed that ACEs did not always occur independently but were always clustered, and there were associations between types of ACEs.<sup>22–23</sup> Clarifying the ACE mode may help to distinguish the individuals with similar ACEs from the rest of the population and provide another perspective on the relationship between ACEs and cognition. Cumulative ACE scores, factor analysis and latent class analysis (LCA) are three common approaches to identifying ACE modes, but factor analysis has not always been applicable because of the high correlation between latent factors.<sup>24</sup> Numerous studies have drawn attention to the clustering of ACEs and accumulated the numbers of ACEs to define ACE modes.<sup>22</sup> However, the method did not consider the associations between ACEs, which may result in misclassification. LCA is a person-centred approach that enables the identification of individuals who share a common ACE mode within a specific subgroup but differ between subgroups, which is a better choice to reflect multidimensional life experiences in a population.<sup>25</sup> Several studies implemented LCA for ACEs and the subgroups were well documented. However, few studies have clarified the relationship between the latent class of ACE and cognitive function.<sup>26–28</sup>

Therefore, the current study aimed to identify the classes of ACEs using LCA in a Chinese population aged  $\geq 60$ , and further tentatively explore the association between ACE classes and cognitive function.

## METHODS

### Data source and participants

We used the data from the China Health and Retirement Longitudinal Studies (CHARLS), which is a national representative study of Chinese adults aged 45+ years. It investigated 150 counties covering 28 provinces using a probability-proportional-to-size sampling technique. The first wave of CHARLS was started in 2011 and followed-up biennially until 2018. The response rate was 83.84% in 2018. The life history survey, which further investigated family information, education history, ACEs, health, wealth and work of the respondents, was supplemented in 2014. The CHARLS was approved by the Ethical Review Committee of Beijing University and all respondents signed informed consent. Detailed information was presented in a previous publication.<sup>29</sup>

The 2014 and 2018 waves included 20 948 participants, from which we excluded the people who were younger

than 60 years ( $N=8600$ ), and those with missing information on the Mini-Mental State Examination (MMSE) ( $N=4088$ ) or any type of ACEs ( $N=1038$ ). Finally, 7222 participants were included in this study.

### Cognitive function

Cognitive function was measured by the Chinese version of the MMSE, which included 30 items and was comprised of five cognitive domains: orientation (10 points), registration (3 points), attention and calculation (5 points), recall (3 points) and language (9 points).<sup>30–31</sup> The MMSE scores ranged from 0 to 30 and higher scores indicated better cognitive function. The threshold of cognitive impairment was  $\leq 17$  for illiterate,  $\leq 20$  for those with 1–6 years of education (not more than primary school), and  $\leq 24$  for those with 7+ years of education (middle school or more) in elderly Chinese people. The tool has a sensitivity of 87.6%, 93.6% and 94.3% for illiterate, individuals with 1–6 years of education and individuals with 7+ years of education, respectively, and a specificity of 80.8%, 92.7% and 94.3% for illiterate, individuals with 1–6 years of education and individuals with 7+ years of education, respectively, in screening for dementia. It has a sensitivity of 68.7%, 66.9% and 79.4% for illiterate, individuals with 1–6 years of education and individuals with 7+ years of education, respectively, and a specificity of 78.0%, 73.6% and 69.6% for illiterate, individuals with 1–6 years of education and individuals with 7+ years of education, respectively, in screening for mild cognitive impairment.<sup>32</sup>

### ACEs

In 2014, the participants were asked whether they had experienced any of 11 types of adverse events at ages younger than 17 years. These events were abuse (physical abuse, emotional abuse), neglect (physical neglect, emotional neglect), household dysfunction (alcohol and/or drug misuser in the household, incarcerated household member, household member chronically depressed and/or mentally ill, household member treated violently, and one or no parents, and parental separation or divorce) and living surroundings (bullying and community violence). They were based on the Adverse Childhood Experiences International Questionnaire designed by the WHO comprised of 13 adverse childhood events, in which the ACEs were cumulatively scored in a range from 0 to 13.<sup>33</sup> The detailed information was published previously.<sup>34</sup>

### Covariates

The potential covariates were comprised of (1) demographic variables (age, gender and residence) and childhood-related variables (self-reported childhood health, father's education, father's occupation and childhood family financial situation); (2) socioeconomic factors (education and household expenditure); (3) health behaviours (tobacco usage, alcohol usage and engaging in social activities); and (4) health status

(hypertension, diabetes, heart problems, stroke, brain damage and depression). Hypertension, diabetes, heart problems and stroke were identified by physicians, and brain damage was measured by the self-reported situations of brain damage or intellectual disability. Depression was measured by the 10-item Center for Epidemiologic Studies Depression Scale.<sup>35</sup> The scale was comprised of eight positive items and two negative items, and the answers were coded on a scale ranging from 0 to 3 based on the frequency of the positive items and the score was reversed for the negative items. Higher scores indicated more severe depressive symptoms, and depression was indicated by scores of  $\geq 10$ .<sup>36</sup>

### Statistical analysis

First, Pearson's correlation analysis was performed to clarify the pairwise correlation between the ACEs. Second, LCA was carried out to identify the classes of ACEs, and the Bayesian information criterion (BIC), which was acknowledged as the best justification for the number of LCA classes, was employed as the criterion for choosing the adequate number of latent classes.<sup>37</sup> The model fit was better for lower BIC values. Importantly, model interpretability and the sample size (generally  $\geq 5\%$  of the total sample) were also considered during the selection process.<sup>24 28</sup> Then, the  $\chi^2$  test, rank-sum test and analysis of variance were performed to compare the distribution of unordered categorical variables, ordered categorical variables and continuous variables between the ACE classes, respectively. Finally, we constructed five binary logistic models to estimate the association between ACE classes and cognitive impairment. In the crude model, we did not adjust for any covariates. Model 1 was adjusted for demographic variables (age, gender and residence) and childhood-related variables (self-reported childhood health, father's education, father's occupation and childhood family financial situation). Model 2 was additionally adjusted for adulthood socioeconomic factors (education and household expenditures) beyond Model 1. Model 3 was additionally adjusted for adulthood health behaviours (tobacco usage, tobacco usage and engaging in social activity) beyond Model 2. Model 4 was additionally adjusted for adulthood health status factors (hypertension, diabetes, heart problems, stroke, brain damage and depression) beyond Model 3.

All analyses were carried out by Stata V.15. The missing proportion of confounders ranged from 0.02% to 20.37% and was calculated by multiple imputations by the chain equation in the 'ice' command.

### Patient and public involvement

Neither the patients nor the public was involved in the conduct, design, analysis or interpretation of this research.

## RESULTS

Table 1 presents the prevalence of ACEs among 7222 participants. Of them, 4199 (58.14%) individuals had

**Table 1** The distribution of ACE types in China Health and Retirement Longitudinal Studies, 2014 (N=7222)

ACE types	n	%
ACEs*	4199	58.14
Physical abuse	469	6.49
Emotional abuse	1532	21.21
Physical neglect	707	9.78
Emotional neglect	1020	14.11
Alcohol and/or drug misuser in the household	113	1.56
Incarcerated household member	23	0.32
Household member chronically depressed and/or mentally ill	1316	18.22
Household member treated violently	1578	21.85
One or no parents, parental separation or divorce	58	0.80
Bullying	416	5.75
Community violence	233	3.22

\*The proportion of the population who had at least one ACE. ACE, adverse childhood experience.

at least one ACE. In terms of the prevalence of each type of ACE, a household member treated violently was the highest (21.85%), followed by emotional abuse (21.21%), a household member chronically depressed and/or mentally ill (18.22%) and emotional neglect (14.11%). The correlation matrix of ACEs showed that most ACEs were related to each other, especially physical neglect and emotional neglect (see online supplemental table S1). Regarding the model-fit indices of the LCA, the BIC declined rapidly from the 2-class model to the 3-class model and reached the lowest point in the 4-class model (see online supplemental figure S1). However, the population of the 4-class model was too small to conduct subsequent regression analysis (2.53% < 5%) and the 3-class model was more interpretable after comparing the distribution of posterior probabilities of ACEs between the two models. Therefore, the 3-class solution was employed in this study.

The three latent classes had specific ACE characteristics (table 2). The first class was characterised as 'Low ACEs' (76.09%), which presented a low proportion of each ACE. The second class was defined as 'Household dysfunction' (15.43%), which showed higher probabilities of a household member being treated violently (0.462) and a household member chronically depressed and/or mentally ill (0.388). The third class was defined as 'Child maltreatment' (8.49%), which was characterised by a higher proportion of emotional neglect (0.980), emotional abuse (0.540), physical neglect (0.414) and physical abuse (0.272).

**Table 2** Latent class prevalence and posterior probabilities from a three-profile latent class analysis model of ACEs

ACE types	Class1	Class 2	Class 3
n (%)	5495 (76.09)	1114 (15.43)	613 (8.49)
Physical abuse	0.013	0.147	0.272
Emotional abuse	0.122	0.320	0.540
Physical neglect	0.049	0.111	0.414
Emotional neglect	0.080	0.005	0.980
Alcohol and/or drug misuser in the household	0.010	0.031	0.020
Incarcerated household member	0.001	0.007	0.009
Household member chronically depressed and/or mentally ill	0.104	0.388	0.262
Household member treated violently	0.119	0.462	0.382
One or no parents, parental separation or divorce	0.009	0.016	0.033
Bullying	0.022	0.155	0.122
Community violence	0.019	0.071	0.077

ACE, adverse childhood experience.

The MMSE score was highest (22.84) in the ‘Low ACEs’ group and smallest (21.59) in the ‘Child maltreatment’ group (see online supplemental table S2). The percentage of cognitive impairment was 13.75%, 14.66% and 18.71% in the ‘Low ACEs,’ ‘Household dysfunction’ and ‘Child maltreatment’ groups, respectively. Most of the covariates showed significant differences between the three latent classes. Compared with the other classes, the people in the ‘Low ACEs’ class seemed to have better childhood health and childhood family financial situations, higher education levels, and were more likely to engage in social activities (48.89% vs 45.93%, 45.44% compared with the ‘Household dysfunction’ and ‘Child maltreatment’ groups, respectively). The population in the ‘Household dysfunction’ class tended to live in rural areas (68.54% vs 61.52%, 60.69%), has a higher proportion of men (54.78% vs 49.13%, 40.72%) and alcohol usage (36.01% vs 31.43%, 27.36% compared with the ‘Low ACEs’ and ‘Child maltreatment’ groups, respectively) and better ability for weight control. People in the ‘Child maltreatment’ class showed a significantly higher proportion of women (59.28% vs 50.87%, 45.22%), higher levels of diabetes (15.09% vs 14.12%, 12.44%),

heart problems (23.74% vs 22.61%, 19.62%), brain damage (14.47% vs 13.58%, 8.91%) and depression (53.77% vs 53.62%, 38.83% compared with the ‘Household dysfunction’ and ‘Low ACEs’ groups, respectively).

Regarding the relationship between ACEs and cognitive impairment (table 3), the ‘Child maltreatment’ class had a 51% (25%–83%) higher risk of cognitive impairment compared with the ‘Low ACEs’ class, whereas the risk of cognitive impairment in the ‘Household dysfunction’ class did not significantly differ from the ‘Low ACEs’ class (crude model). When adjusting for the demographic and childhood-related variables (Model 1), the OR of ‘Child maltreatment’ decreased to 1.44 (1.18–1.76). After controlling for the socioeconomic and health behaviour factors beyond Model 1, there was a minor decline in the effects compared with Model 1. After considering all the childhood and adulthood covariates in Model 4, the effect of ‘Child maltreatment’ on cognitive impairment decreased to 1.37 (1.12–1.68).

## DISCUSSION

In general, this study identified ACE classes using LCA and tentatively explored the association between ACE

**Table 3** Estimates of the effect of ACE classes on cognitive impairment

ACE class	Crude	Model 1	Model 2	Model 3	Model 4
Class 1	Ref	Ref	Ref	Ref	Ref
Class 2	1.12 (0.96, 1.32)	1.11 (0.94, 1.31)	1.10 (0.93, 1.30)	1.10 (0.93, 1.30)	1.06 (0.90, 1.26)
Class 3	1.51 (1.25, 1.83)	1.44 (1.18, 1.76)	1.43 (1.17, 1.75)	1.42 (1.16, 1.74)	1.37 (1.12, 1.68)

Class 1, Low ACEs; Class 2, Household dysfunction; Class 3, Child maltreatment.

The crude model did not adjust for any covariates. Model 1 was adjusted for covariates (age, residence, father’s education, father’s occupation, childhood health and childhood family financial situation). Model 2 was additionally adjusted for adulthood socioeconomic factors (education and household expenditures) beyond Model 1. Model 3 was additionally adjusted for adulthood health behaviours (tobacco usage, alcohol usage and engage social activity) beyond Model 2. Model 4 was additionally adjusted for adulthood health status factors (hypertension, diabetes, heart problems, stroke, brain damage and depression) beyond Model 3.

ACE, adverse childhood experience.



classes and cognitive function among elderly Chinese people. About 60% of the people reported at least one ACE, which was similar to the prevalence in the USA, Sweden and England.<sup>1 2 38</sup> Three latent ACE classes were identified, and the classes differed with respect to the probability of the type of ACE. Most of the population was classified as the 'Low ACEs' class, followed by the 'Household dysfunction' class and the 'Child maltreatment' class. With regard to the relationship between ACEs and cognitive function, only the 'Child maltreatment' class was related to a higher risk of cognitive impairment compared with the 'Low ACEs' class.

The ACEs classes identified in this study were similar to previous classifications<sup>39 40</sup> and the latent classes in other previous studies.<sup>26 27</sup> The participants in the 'Household dysfunction' class had a relatively higher probability of endorsing child abuse, while 'Child maltreatment' had a higher probability of endorsing household dysfunction. This finding was consistent with the findings of prior studies.<sup>41 42</sup> Parents living with household dysfunction found it more difficult to handle emotional dysfunction (such as impulsivity, frustration and anger), manage their daily lives, and maintain a warm and secure environment for their children, which was related to a higher risk of child maltreatment.<sup>42</sup> Nevertheless, contrary to being clustered with parental separation, incarceration and alcohol abuse in prior studies,<sup>26 27</sup> the 'Household dysfunction' class in this study had a higher probability of having a chronically depressed and/or mentally ill household member or household member treated violently. This finding may have been due to different legal provisions (such as legal restrictions on granting a divorce in China) and the lower prevalence of substance abuse between the countries<sup>43 44</sup> and suggested that the clustering of some ACEs may be discrepant between people of different cultural backgrounds.

Of note, we also found that ACEs were associated with worse childhood health status and family financial situations, lower adulthood education levels and a higher risk of health problems in later life. Prior studies found that childhood socioeconomic status (SES) was an important predictor of ACEs,<sup>45 46</sup> and ACEs were related to lower adulthood socioeconomic levels (including lower levels of adult education and income).<sup>47</sup> However, although the people living in urban areas always have a higher SES in China, only a subtle nuance in the proportion of rural residences between the 'Low ACEs' class and the 'Child maltreatment' class was observed. A previous study pointed out that parenting style patterns were strongly associated with child maltreatment, especially in children with higher SES levels.<sup>48</sup> Furthermore, 'stick education,' in which parents discipline children using violence (such as physical abuse and household violence)<sup>49</sup> has prevailed in Chinese families in the last century. Therefore, parenting styles should be considered in efforts to prevent ACEs.

The results showed that the 'Child maltreatment' class was independently related to a higher risk of cognitive impairment.<sup>13 18 19</sup> One possible biological mechanism reported by prior studies was that ACEs may alter the brain structure during sensitive periods,<sup>10 11</sup> and the change may result in less efficient memory and executive functions including initiation and non-verbal reasoning.<sup>12 13</sup> In addition, ACEs related to lower adult SES levels, worse physical and mental health statuses, a lower ability for emotional management and lower levels of social support, which accumulated over the lifetime, had adverse cumulative effects on cognitive function.<sup>20 22</sup>

Some studies presented inconsistent or opposing findings. For example, one study found that childhood abuse did not increase the risk of cognitive impairment, and another study showed that physical abuse and child mistreatment were related to better cognitive function.<sup>17 21</sup> The differences in the findings may be due to the relatively higher proportion of women in 'Child maltreatment' group in the present study. Because 'patriarchal' families were prevalent in the last century in China,<sup>50</sup> women received less attention from their parents and were punished with violence (such as physical abuse and household violence).<sup>51</sup> Besides, evidence has shown that childhood maltreatment was related to internalising psychopathology disorders such as depression, anxiety or panic among women.<sup>52</sup> The harmful effect of childhood maltreatment could accumulate to result in worse cognitive function.

Furthermore, contrary to the evidence that 'Household dysfunction' increased the risk of cognitive deficits in children in other studies, our study did not observe an association with cognitive impairment in late life.<sup>53–55</sup> Based on differential preservation and preserved differentiation patterns, the high-risk subgroup always had worse cognitive functions or steeper cognitive declines across their lifespan.<sup>56</sup> However, the cognitive reserve could increase the resilience of the brain and explain the different rates of cognitive decline.<sup>57</sup> Education was shown to be an important indicator of cognitive reserve, which may be associated with the similar 'Junior high school or less' rate between the 'Low ACEs' group and the 'Household dysfunction' group.<sup>58</sup> In addition, the MMSE, which is a lower sensitivity screener of cognitive deficits, may be a reason for the inconsistent outcomes.

There were some limitations to the present study. First, the CHARLS did not include all types of ACEs, such as contact sexual abuse and collective violence, where sexual abuse was proved to be related to other ACEs and was positively and extensively related to cognitive function in other countries.<sup>23 59</sup> The 'Child maltreatment' class of ACEs identified by LCA included sexual abuse in a prior study.<sup>26</sup> Therefore, removing sexual abuse may not affect the general latent classes of ACEs, but may underestimate the effect of 'Child maltreatment' and cognitive impairment. Second, the ACEs values were based on a retrospective investigation rather than a prospective cohort, which is a common limitation in ACE-related studies and

possibly underestimated the prevalence of ACEs.<sup>60 61</sup> In this study, we chose to analyse the frequency of ACE occurrences, which may be more valid to measure.<sup>60</sup> Finally, cognitive impairment identified by the MMSE, which has a lower sensitivity for mild cognitive impairment, may not efficiently clarify the relationship between ACEs and early cognitive dysfunction.<sup>32</sup> This limitation may have caused a misinterpretation of the relationship between the 'Household dysfunction' class and cognitive impairment. Future studies can verify this association using validated tools for measuring cognition.

## CONCLUSION

This study explored the heterogeneity of the ACE classes and the relationship between ACE classes and cognitive function using a nationally representative sample of elderly Chinese people. The findings showed that ACEs were clustered and could be classified as 'Low ACEs,' 'Child maltreatment' and 'Household dysfunction'. The 'Child maltreatment' class was independently related to a higher risk of cognitive impairment. The study findings support the association between ACE and cognitive deficits and provide new insight into the relationship between ACE and cognitive function.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not applicable.

**Ethics approval** This study involves human participants and was approved by the Ethical Review Committee of Beijing University, IRB00001052-11015. Participants gave informed consent to participate in the study before taking part.

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