

# Joint trajectories of lifestyle pattern and subsequent psychopathological outcomes in adolescence

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## Research article

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# Abstract

**Background:** Rapid socio-economic development makes China a unique laboratory for examining how lifestyle changes affect adolescent mental health. This study aims to identify joint trajectories of modifiable lifestyle indicators during pubertal transition and its associations with psychopathological outcomes.

**Methods:** A cohort of 1974 children aged 7-9 years were recruited in Anhui Province, China during March 2013. The assessment of lifestyle behaviors (screen time, physical activity, sleep duration and beverage intake) and depressive symptoms were conducted from Wave 1 to Wave 4 (2018). Suicide ideation, non-suicidal self-harm (NSSI) and alcohol use were self-reported at Wave 4. Longitudinal trajectories of lifestyle patterns were defined using group-based multi-trajectory models in 2019.

**Results:** Four lifestyle trajectories were identified: persistent healthy (39.9%), suboptimal healthy (25.3%), unhealthy mitigation (17.2%), and persistent unhealthy (17.7%). Compared with persistent healthy group, the risk of subsequent suicide ideation [odds ratio (OR): 2.86, 95%CI: 2.15-3.81], depressive symptoms (OR: 2.16, 95%CI: 1.39-3.35), alcohol use (OR: 2.53, 95%CI: 1.78-3.61) and non-suicidal self-harm (OR: 1.35, 95%CI: 1.09-1.67) was significantly higher in persistent unhealthy group.

**Conclusions:** This study provided convincing evidence that unhealthy lifestyle trajectory during adolescence would substantially confer more than two-fold elevated risk for multiple domains of psychopathological outcomes over 5 years.

## Introduction

The past three decades brought tremendous changing in the socio-economic context of adolescent development in China with implications for mental health. China is heading towards a ballooning epidemic of mental health problems in teens (1-3). The preliminary results of a nationwide epidemiological study suggest that 15% of children suffer from mental health problems and the prevalence of some disorders, such as anxiety disorders, are increasing (4). The 12-month prevalence of non-suicidal self-injury (NSSI), suicidal ideation and suicide attempt was 26.1%, 17.5% and 4.4%, respectively, based on a population of 14 820 students aged 10-20 years from three provinces in China (1).

Such soaring of mental health problem has paralleled a dramatic shift in health-related behaviors and lifestyle from traditional, healthy patterns towards unhealthy patterns. During the transition from childhood to adolescence, children in China gradually develop its unique lifestyle pattern due to high level academic pressure compared with their counterparts in western countries, including prolonged sitting and screen time (5,6), high proportion of regular sugar-sweetened beverages (SSBs) consumption (7) and insufficient sleep (8).

The role of lifestyle in the causation of mental health has long been established and provoked recommendations regarding diet, sedentary activity (primarily screen time), physical activity (PA), and sleep (9). Recent meta-analyses of prospective studies also concluded inverse associations of PA with depression in youth (11) Schuch et al., 2018) and children (11). Our previous work explored the potential importance of eating patterns for mental health in 14 500 adolescents at grade 7-12 from 32 schools in 4 provinces across China (12). A significant dose-response relationship was found between SSBs consumption pattern with higher risk of psychological symptoms during adolescence. Recently, Trondheim Early Secure Study, a population-based cohort study in Norway, found an association between short sleep duration and increased risk of future occurrence of emotional disorder symptoms in both boys and girls and between reduced sleep and behavioral disorder symptoms in boys (13).

As evidence continues to accumulate on emerging lifestyle risk factors during childhood and adolescence tend to cluster within individuals and may have synergistic effects on health (14,15). The majority of studies tended to focus on single behavior or summed multiple behaviors into an index score (8,16). Few investigations have examined longitudinal trajectory of multiple lifestyle risk factors as children develop into adolescence (17,18).

Adolescents establish patterns of behavior and make lifestyle choices that affect both their current and future health and well-being (19,20). The onset of adolescence represents an important turning point in the individual's development, not only from a psychological point of view, but also with regard to the emergence of psychopathology (21). Given the importance of this transitional period and the acute need for targeted preventive efforts, as well as the high prevalence of depressive symptoms, non-suicidal self-injury and suicide behaviors among Chinese children and adolescents (22), one of the aims of this longitudinal study was to gather information on developmental trajectory of a combination of modifiable, health-related behaviors among Chinese children over the transition to adolescence, and to evaluate their longitudinal associations with self-destructive behaviors (non-suicidal self-harm, suicide ideation) and psychiatric symptoms (depressive symptoms), as illustrated in the conceptual framework (**Figure 1**).

## Methods

### Study design and participants

The present study used data of an ongoing longitudinal study examining psychosocial determinants of growth and development in Anhui Province, China. As illustrated in **Fig. 1**, of a possible 2025 students in grade 1 to 3 from four large elementary schools of Bengbu city, 1974 (1104 boys, 55.9%) agreed to participate. Bengbu, located in north Anhui Province, is a significant traffic hub in east China. Great economic and social achievements have been made in the past decade. The gross domestic product per capita (GDP) increased by over 12% annually, doubling the figure of the former period before 2010. It is one of the representative cities in China in terms of its urbanization and industrial development.

Students were initially aged 7 to 9 years in the first wave of data collection (March 2013). Subsequent wave of data collection took place 2 years (wave 2), 4 years (wave 3) and 5 years (wave 4) later. The

study approval from Institutional Review Boards at Anhui Medical University and then obtained written informed consent from parents and school teachers, as well as child assent. which they were requested to complete and return if they did not want their child to participate in the study or if their child did not want to.

Parents of the students completed baseline questionnaire survey at home. In later waves, all the students completed the questionnaires on their own. Students' data collection was conducted in a class setting at schools with a supervising research assistant available to answer questions following a standard script.

## **Measurements**

### **Lifestyle Factors**

#### *Physical activity*

Youth physical activity levels were ascertained from the Youth Risk Behavior Survey 2013 (YRBS;23) at each wave. Parents (wave 1) and adolescents (wave 2-wave 4) were asked "During the past 7 days, on how many days were your child (you) physically active for a total of at least 60 minutes per day?".

#### *Screen time*

Weekly average screen time was derived for each child based on daily time (hours) spent on screen during weekdays and weekends (including watching television/video, playing computer, iPad and smartphone).

#### *Sugar-sweetened beverage consumption (SSBs)*

Sugar-sweetened beverage consumption was assessed through the question 'During the past 7 days, how many times did your child (you) drink at least 1 serving regular sugar-sweetened sodas, fruit drink, sweetened iced tea, sports /energy drink that contains sugar?'

#### *Sleep duration*

Sleep duration was estimated by subtracting self-reported waketime from bedtime, assessed by asking, "On a usual weekday this past week, when did your child (you) go to bed at night?" and "On a usual weekday this past week, when did your child (you) wake up the next morning?"

## **Outcomes**

### *Baseline Depressive Symptoms Assessment*

The Short Mood and Feelings Questionnaire Parent-report (SMFQ-P) has been widely used in children aged 6 to 17 years, including our previous work (24-26). Cronbach's alphas for our sample were high (0.85). In keeping with previous research, depressive symptoms were defined as having an SMFQ-P score of 11 or greater (26).

### *Follow-up Depressive Symptoms Assessment*

The Mood and Feelings Questionnaire (MFQ) was used at wave 2-4 (27). Adolescent self-reported current or past 2 weeks' depressive symptoms. The MFQ has shown prognostic validity in clinic and non-clinic samples (28), yielding high internal consistency ( $\alpha=0.91-0.93$ ) in the present sample. Adolescents with total scores of 29 or above on the MFQ was considered depressive (29).

### *Suicide ideation*

At wave 4 (2018), adolescents were asked a specific question to assess suicide ideation (“Have you ever seriously thought about killing yourself and, if so, have you had these thoughts in the past 12 months?”) from a section of the World Mental Health CIDI (WMH-CIDI) (30).

### *Non-suicidal self-harm behaviors*

At wave 4 (2018), adolescents were asked “Have you ever harmed yourself in a way that was deliberate, but not intended as a means to take your life in the last (reference period)?” (1). A list of eight non-suicidal self-harm (NSSI) (hitting, pulling hair, banging head, pinching, scratching, biting, firing/burning, cutting) methods was then presented.

### *Alcohol use*

Alcohol use at wave 4 (2018) was defined as having at least one drink of alcohol during the past 30 days (31).

## **Covariates**

### *Body mass index*

At each wave, height and weight was measured and body mass index (BMI) was calculated as weight (in kg) divided by height squared (in m).

### *Parental education and family monthly income*

Parents at baseline reported educational attainment during the consent process and family monthly income from “1” for “<2,000 RMB” (ca. 313 US\$) to “5” for “>15,000 RMB” (ca. 2345 US\$).

### *Warm parenting*

All parents were questioned a 13-item scale adapted by Raudino et al. (2012) (32). from the Child Rearing Practices Report and the Parenting Scale. Cronbach's alpha in the current study was 0.91.

### *Adverse Childhood Experiences*

At wave 4 (2018), adolescents reported experience with 10 adverse events including abuse and neglect by using the 10-item Adverse Childhood Experiences Questionnaire - Short Form (ACES-SF) (33,34). Eight items from this measure were included. A total score with higher values indicating greater experience of childhood adversity. Cronbach's alpha in the current study was 0.75.

## Statistical Analysis

The study sample was characterized using descriptive statistics and frequency distributions at baseline and across following three waves. Average level of four lifestyle behaviors over time were analyzed by three-way repeated measures analysis of variance (ANOVA) with time, sex, family income, maternal education, and weight status as factors. Multiple comparisons were assessed by Bonferroni post-hoc test.

Group-based multi-trajectory modeling, a generalization of univariate group-based trajectory modeling to multiple outcomes (35), was adopted to examine latent clusters of children with similar lifestyle trajectories across the four lifestyle behaviors: weekly screen time, physical activity, sleep duration, and SSBs consumption. The number of classes that best fit was selected based on model fit comparisons using a series of standard fit indices (i.e., Bayesian Information Criterion [BIC], sample-size-adjusted BIC [SSABIC], Akaike Information Criterion).

After the lifestyle multi-trajectory profiles were identified, preliminary analyses calculated descriptive statistics and tested lifestyle trajectory group differences in terms of depressive symptoms across four waves, as well as suicide ideation, alcohol use and non-suicidal self-harm assessed in Wave 4.

The associations between longitudinal changes in depressive symptoms and lifestyle trajectory groups examined using mixed-effects logistic growth modeling, controlled for age, sex, family monthly income, maternal education, and childhood adverse experiences.

Multiple logistic regression model was performed to examine association between suicide ideation, alcohol use and non-suicidal self-harm with four lifestyle trajectory groups. In these models, the four lifestyle trajectories were treated as nominal variables with the persistent healthy lifestyle class serving as the reference group.

Analyses were performed using STATA Software Version 14 (College Station, TX: StataCorp LP; 2015). A *P*-value <0.05 was considered statistically significant.

## Results

### General information

**Table 1** describes baseline characteristics of the 1974 children (mean age 8.1 years, SD 0.87 at baseline) were included. More than half (55.9%) were male. Over one-fourth of children at baseline were overweight (16.2%) or obese (12.4%). Less than 5% of the participants come from low-income families. Among those

who did not provide information on depressive symptoms, suicide ideation, NSSI and alcohol use, no significant differences were found in proportion of boys, baseline SMFQ score and family monthly income, except that boys were more likely missing depressive symptoms in wave 2 (**Appendix Table 1**).

### **Longitudinal changes in health behaviors across four waves**

Three-way repeated measures ANOVA revealed significant increasing trend for physical activity ( $F_{3,5848} = 168.43, P < 0.001$ ) and SSBs consumption ( $F_{2,5848} = 138.06, P < 0.001$ ), while decreasing trend for screen time ( $F_{3,5848} = 110.96, P < 0.001$ ) and sleep duration ( $F_{3,5848} = 1053.09, P < 0.001$ ), after adjusting for sex, family income, maternal education, and weight status (**Table 1**).

### **Group based multi-trajectory analysis of lifestyle patterns**

Multi-trajectory analysis of the longitudinal behavior data on 1974 children revealed four distinct trajectories of lifestyle patterns (model fit statistics see **Appendix Table 2**). **Fig. 2** shows the estimated mean levels in the four health-related behaviors at four waves for each trajectory group.

About 39.9% (802/1974) of children maintained a stable-low level of screen time (2.4 h/d to 1.4 h/d, in wave 1 and wave 4, respectively; the same hereinafter) and SSBs intake (0.2 times/wk to 1.7 times/wk) with high-increasing physical activity (2.4 d/wk to 3.5 d/wk), albeit the general decreasing trend in sleep duration (9.4 h/d to 8.4 h/d), throughout the 5-year follow-up (persistent healthy group)

More than one in four children (439/1974, 25.3%) were classified as suboptimal healthy group who started with healthy behaviors, but then experienced a substantial increase in SSBs intake (0.8 times /wk to 3.3 times/wk) and a slightly shorter sleep duration (9.4 h/d to 8.1 h/d);

Nearly 17.2% (332/1974) of children were classified as “unhealthy mitigation group”, who were characterized with high-decreasing screen time (3.0 h/d to 2.1 h/d), low-increasing physical activity (1.3 d/wk to 2.6 d/wk) and high-decreasing SSBs intake (4.4 times/wk to 2.5 times /wk), albeit decreasing trend in sleep duration (9.4 h/d to 8.0 h/d);

About 17.7% (401/1974) of children were identified as “persistent unhealthy group”, who were characterized with excessive screen time (4.2 h/d to 3.2 h/d), abrupt decrease in sleep duration (9.4 h/d to 7.5 h/d) and stable-high SSBs intake (1.3 times/wk to 3.2 times/wk), albeit increasing physical activity (2.0 d/wk to 3.4 d/wk). The mean posterior probability for each trajectory group exceeded 0.92, while other fit statistics also confirmed that the four latent trajectory groups were optimal for our study data.

### **Association of four lifestyle trajectory groups with psychopathological outcomes**

**Table 2** describes the comparison of prevalence in depressive symptoms, suicide ideation, alcohol use and NSSI across trajectory groups. The prevalence of depressive symptoms across four waves was significantly higher in the unhealthy persistent group compared to both the persistent healthy and the

suboptimal healthy groups (6.7% vs. 2.5% and 1.6% at baseline,  $P < 0.05$ ; 21.3% vs. 11.3% and 8.3% at wave 4,  $P < 0.001$ ).

Approximately 1 in 5 (19.9%) children reported suicide ideation in the unhealthy persistent group, compared with 1 in 14 (7.1%) in healthy group ( $P < 0.001$ ). Alcohol use and NSSI was both significantly more frequent in the unhealthy persistent compared to the healthy groups (11.8% vs. 3.5% for alcohol use,  $P < 0.001$ ; 30.7% vs. 19.5% for NSSI,  $P < 0.01$ ).

A similar pattern was observed in the unhealthy mitigation group. Depressive symptoms, suicide ideation and alcohol use over 5 years follow-up were significantly higher compared with healthy groups (18.8% vs. 9.3% for depressive symptoms,  $P < 0.001$ ; 13.8% vs. 7.1% for suicide ideation,  $P < 0.001$ ; and 6.4% vs. 3.5% for alcohol use,  $P < 0.01$ ).

### **Prediction of psychopathological outcomes by the four distinct trajectory groups**

The results from the logit regression analyses show the association between the four lifestyle trajectory groups psychopathological outcomes adjusted for age, BMI, sex, family income, parental education, warm parenting and adverse childhood experiences in Wave 4 (**Fig. 3**). “Unhealthy persistent” lifestyle trajectory was associated with an odds ratio (OR) of 2.86 (95%CI, 2.15-3.81) for suicide ideation, 2.16 (95%CI, 1.39-3.35) for depressive symptoms, 2.53 (95%CI, 1.78-3.61) for alcohol use, and 1.35 (95%CI, 1.09-1.67) for NSSI compared with children with healthy lifestyle trajectory.

In addition, children in “unhealthy mitigation” trajectory also had a higher chance of suicide ideation [OR (95%CI) = 1.86 (1.37-2.52)], and depressive symptoms [OR (95%CI) = 1.96 (1.23-3.12)] compared to the healthy group (**Fig. 3**).

## **Discussion**

Using data from a cohort of children over the transition from childhood to adolescence, this is the first study to our knowledge to map and identify the developmental trajectories of multiple lifestyle factors, as well as its distinct relations with psychopathological outcomes over 5 y of follow-up. Our findings identified that less than 40% of Chinese children belonged to a healthy lifestyle, and 1 in 5 were classified into a persistent unhealthy lifestyle combining stable-high screen time and SSBs intake with abrupt decrease in sleep duration (less than 8 h/d), which was independently associated with two-folds elevated risk for multiple domains of psychopathology, including suicide ideation, depressive symptoms, alcohol use, and non-suicidal self-harm.

The transition from childhood to adolescence has been seen as a crucial phase where unhealthy behaviors are adopted or discarded and tend to cluster as a result of changing roles and situations (36). To date, there are increasing investigations of longitudinal trajectories of multiple health behaviors in children and adolescents (17,37,38). However, most of the longitudinal trajectory for variables of interest were analyzed for individual healthy behavior separately rather than jointly, potentially overestimating the

effect of single health behaviors as unhealthy behaviors tend to cluster (39,40), particularly evident during adolescence. The virtue of the group-based multi-trajectory modeling used in this study is that it highlights heterogeneity in the linkage between trajectories of multiple intrinsically relevant behaviors (35).

Evidence is accumulating on the mental health effects of modifiable lifestyle patterns among children and adolescents, however, most of these studies examined the association for specific behaviors. For example, researches showed that healthy lifestyle such as sufficient physical activity and sleep associated with a lower risk of youth suicidal ideation (41). One recent meta-analysis from Korczak et al. (2017) (11) suggested that physical inactivity was associated with increased concurrent depressive symptoms; but the association with future depressive symptoms was weak due to a small number of longitudinal studies. Babic et al. (2017) (42) and others (43) found a clear inverse association between total recreational screen-time and computer use with psychological well-being. Such evidence is further supported by our study, indicating that the vulnerability for multiple domains of psychopathological outcomes during adolescence is proportional to the developmental trajectories of unhealthy lifestyle factors.

Our results that adolescents in “unhealthy mitigation group” had similar risk for subsequent suicide ideation and depressive symptoms with those in “persistent unhealthy group”, which was in line with Carli and his colleagues (37). In their cross-sectional study of 12,395 adolescents from 11 European countries, the authors identified three groups of pupils, including high-risk group (13.2%) who scored high on all risk behaviors and “invisible risk” group (29%) who were positive for high screen time, sedentary behavior and reduced sleep. Results suggest that these two groups had similar prevalence of suicidal thoughts, subthreshold depression and depression. Children in the “unhealthy mitigation” group are characterized with high-decreasing screen time, low-increasing physical activity and high-decreasing SSBs intake, suggesting developmental vulnerability may psychopathological vulnerability might be initially set by early childhood risky health-related behaviors, improvement in healthy lifestyle during adolescence are not adequate enough to mitigate the effects of existing risks. This population of children may represent an important “invisible” intervention target group for potentially reducing psychopathology and other untoward outcomes in adolescence.

Children from the persistent unhealthy group reported stable-moderate level of physical activity, suggesting that greater vulnerability for psychopathology might have been caused by the other three components of the high-risk lifestyle behaviors (excessive screen time and SSBs intake, insufficient sleep) irrespective of moderate physical activity.

The present study comprehensively assessed the longitudinal relationship between a combination of multiple repeatedly-assessed lifestyle behaviors and various psychopathological outcomes in Chinese children and adolescents. Health behaviors were assessed starting in childhood, before the first signs of psychopathology, making it less prone to bias from reverse causation. This study applied an innovative

analytic approach—group-based multi-trajectory analysis—that allows for the identification of diverse developmental trajectories of four lifestyle behaviors.

The contributions of this study should be viewed with its limitations in mind. First, all data were collected through parent- or self-report, potentially causing misclassification. The lack of accelerometry-measured physical activity data limited our ability to capture the complexity of the physical activity and sedentary behavior patterns comprehensively. accelerometer-derived measures of sleep and rest-activity patterns and use them to further understand the biology of sleep. Another limitation of this study is the reliance on self-reported of usual sleep hours to reflect an average of sleep durations. Future work should use multiple measures the characteristics of sleep quality, including objective measures. Thirdly shorter sleep length can also be regarded as a symptom of psychopathology which might yield inflated correlations due to shared method variance. Fourthly, a small proportion of adolescents (10%) missed questions related to psychopathological outcomes despite a similar demographic characteristics and baseline depressive symptoms compared with those included. Furthermore, this study has the inherent limitation of residual confounding due to unmeasured covariates, such as genetic background, which could make associations a poor estimate of causal effects. Finally, this study conducted in a specific geographic region in China, and the findings may not be generalizable to adolescents across China.

## Conclusion

This prospective cohort of Chinese children provides convincing epidemiological evidence that an unhealthy lifestyle during childhood would substantially confer more than two-fold elevated risk for suicide ideation, non-suicidal self-harm, depressive symptoms and alcohol use over a period of 5 years. This study provides a basis for quantitative estimates for the potential effect of a population-based lifestyle intervention on the growing burden of mental disorders in China, especially among adolescents and emerging adults. Extended follow-up of this cohort would provide further evidence of the long-term impact of overall lifestyle modification in mental health promotion.

## Abbreviations

PA, physical activity; SSBs, sugar-sweetened beverages.

## Declarations

**Ethics approval and consent to participate:** The study approval from Institutional Review Boards at Anhui Medical University and then obtained written informed consent from parents and school teachers, as well as child assent. which they were requested to complete and return if they did not want their child to participate in the study or if their child did not want to.

**Consent for publication:** Not applicable.

**Availability of data and materials:** The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Competing interests:** The authors declare that they have no conflict of interest.

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### **Authors' contributions**

Ying Sun, Fang-biao Tao, Yu-hui Wan and Pu-yu Su contributed to study concept and design, interpretation and critical revision of article. An-hui Zhang, Dan-dan Zhang, Yu-hui Wan, Pu-yu Su carried out the study. Ying Sun, An-hui Zhang and Dan-dan Zhang contributed to the writing of the article data analysis. All authors have read and approved the manuscript.

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## Tables

**Table 1** Descriptive Analysis of Lifestyle Measures across Four Waves among Chinese Children, Mean (SD)

	Wave 1	Wave 2	Wave 3	Wave 4	Main effect of time <sup>a</sup>
Participants, n	1974	1949	1899	1795	
Boys	1104 (55.9)	1087 (55.8)	1060 (55.8)	1001 (55.8)	
Family monthly income					
<2000 RMB	80 (4.1)	79 (4.1)	76 (4.0)	74 (4.1)	
2000 -5000 RMB	1061 (53.7)	1053 (54.0)	1021(53.8)	960(53.5)	
5000-10000 RMB	633 (32.1)	621 (32.0)	611 (32.2)	581 (32.4)	
10000-15000 RMB	151 (7.6)	148 (7.6)	145 (7.6)	138 (7.7)	
>15000 RMB	49 (2.5)	48 (2.5)	46 (2.4)	42 (2.3)	
Maternal education					
< high school	463 (23.5)	459 (23.6)	437 (23.0)	405 (22.6)	
high school	972 (49.2)	957 (49.1)	937 (49.3)	900 (50.1)	
bachelors/ graduate	539 (27.3)	533 (27.3)	525 (27.6)	490 (27.3)	
Body mass index, kg/m <sup>2</sup>	16.75±2.9	19.79±3.7	20.26±3.9	20.93±4.0.	377.17 §
ST, h/d	2.94 (1.8)	2.71 (2.1) §	2.17 (1.9) §	1.92 (1.4) §	110.96 §
PA ≥1h/d, d/w	2.38 (1.9)	2.63 (2.0) ‡	3.60 (1.8) §	3.52 (1.7) §	168.43 §
Sleep duration, h	9.39 (0.5)	9.16 (0.6) §	8.53 (0.7) §	8.06 (0.7) §	1053.09 §
SSBs≥1 serving, d/w	1.51 (2.0)	1.78 (1.8) §	2.55 (1.9) §	-	138.06§

Abbreviations: ST, screen time; PA, physical activity; SSBs, sugar-sweetened beverages.

<sup>a</sup> Three-way repeated measures ANOVA (time, sex and family monthly income, maternal education and weight status as factors) and Bonferroni post-hoc test, †  $P<0.05$ ; ‡  $P<0.01$ ; §  $P<0.001$

**Table 2** Prevalence of depressive symptoms, suicide ideation, alcohol use and non-suicidal self-harm across four lifestyle trajectory groups in the longitudinal lifestyle data on 1974 children

Outcomes	Participants	Prevalence n (%)	Lifestyle Multi-trajectories <sup>a</sup> [N (%)]			
			Healthy	Suboptimal Healthy	Unhealthy Mitigation	Unhealthy Persistent
<b>General</b>	1974		787 (39.9)	499 (25.3)	339 (17.2)	349 (17.7)
<b>Depressive symptoms</b>						
Baseline	1974	75 (3.8)	20 (2.5)	7 (1.6)	21 (6.3) †	27 (6.7) †
Wave 2	1893	116 (6.1)	29 (3.8)	13 (3.1)	17 (5.4)	57 (14.5) §
Wave 3	1846	184 (10.0)	53 (7.0)	21 (5.1)	38 (12.5) †	72 (19.4) §
Wave 4	1761	230 (13.1)	67 (9.3)	32 (8.1)	55 (18.8) §	86 (21.3) §
<b>Suicide ideation</b>	1762	191 (10.8)	50 (7.1)	39 (8.6)	41 (13.8) §	61 (19.9) §
<b>Alcohol use</b>	1760	105 (6.0)	25 (3.5)	25 (5.5)	19 (6.4) †	36 (11.8) §
<b>Non-suicidal self-harm</b>	1763	403 (22.9)	138 (19.5)	103 (22.7)	68 (22.8)	94 (30.7) ‡

<sup>a</sup> Compared with healthy lifestyle persistent group, †  $P < 0.05$ ; ‡  $P < 0.01$ ; §  $P < 0.001$

## Figures

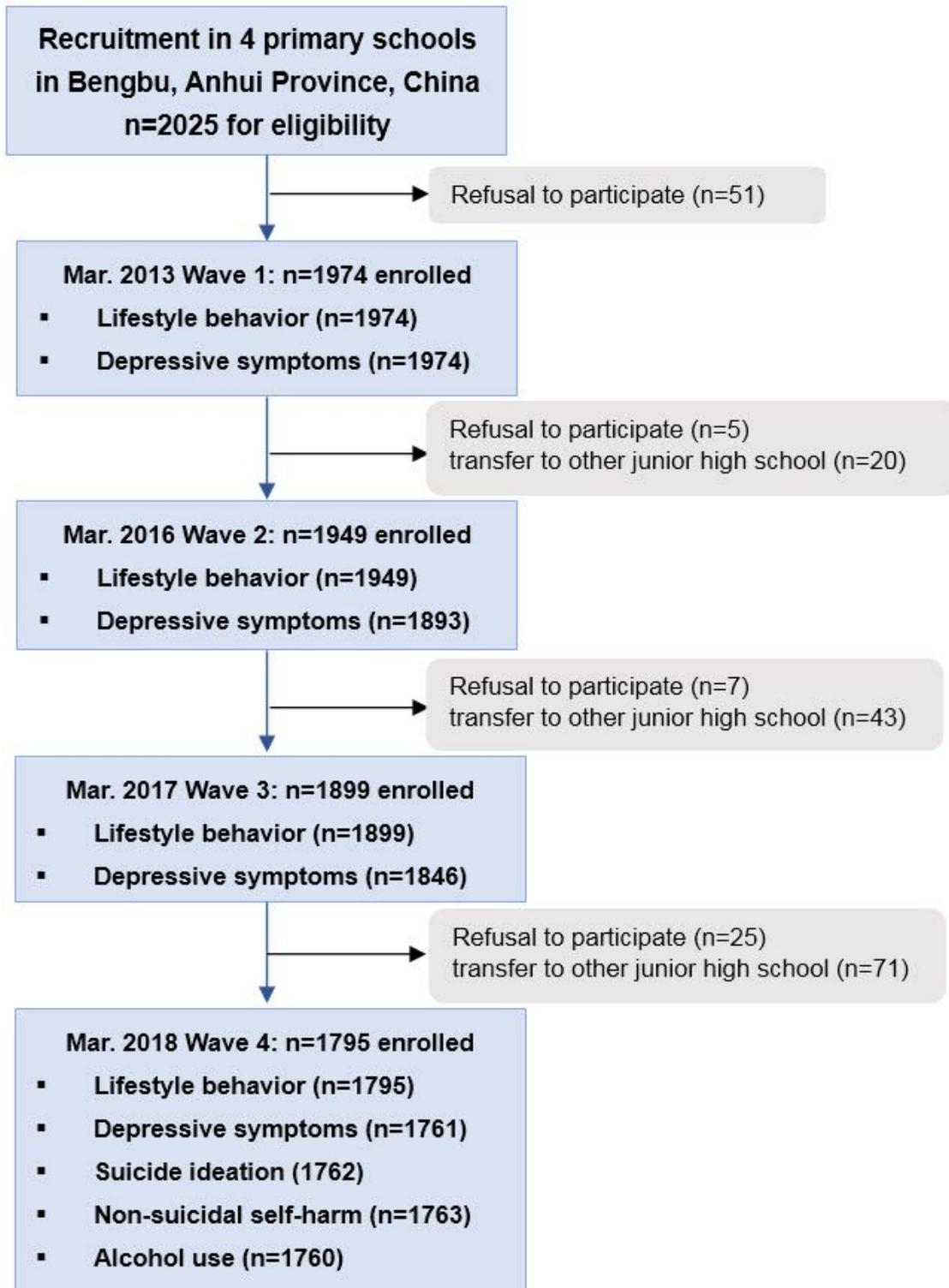
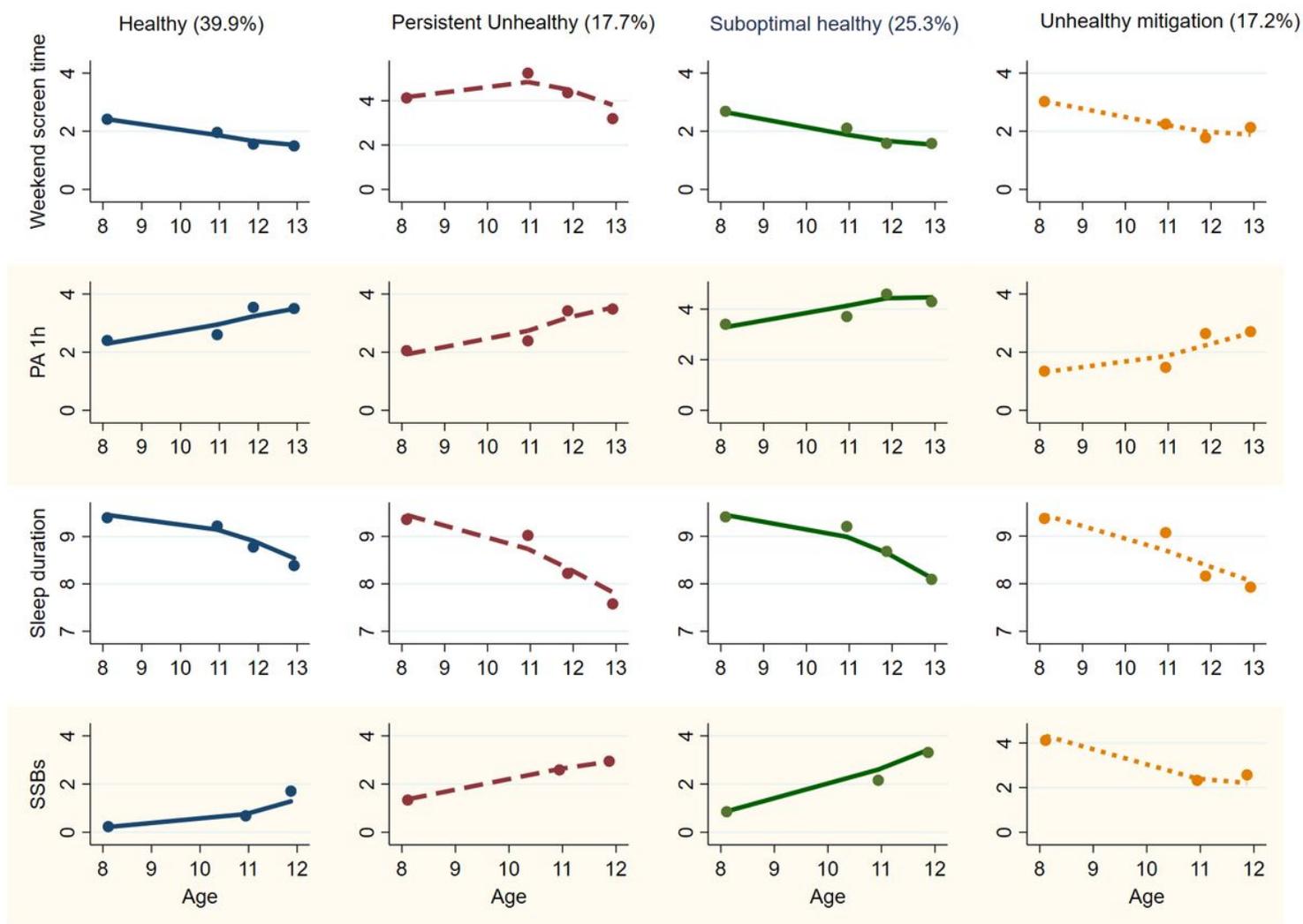


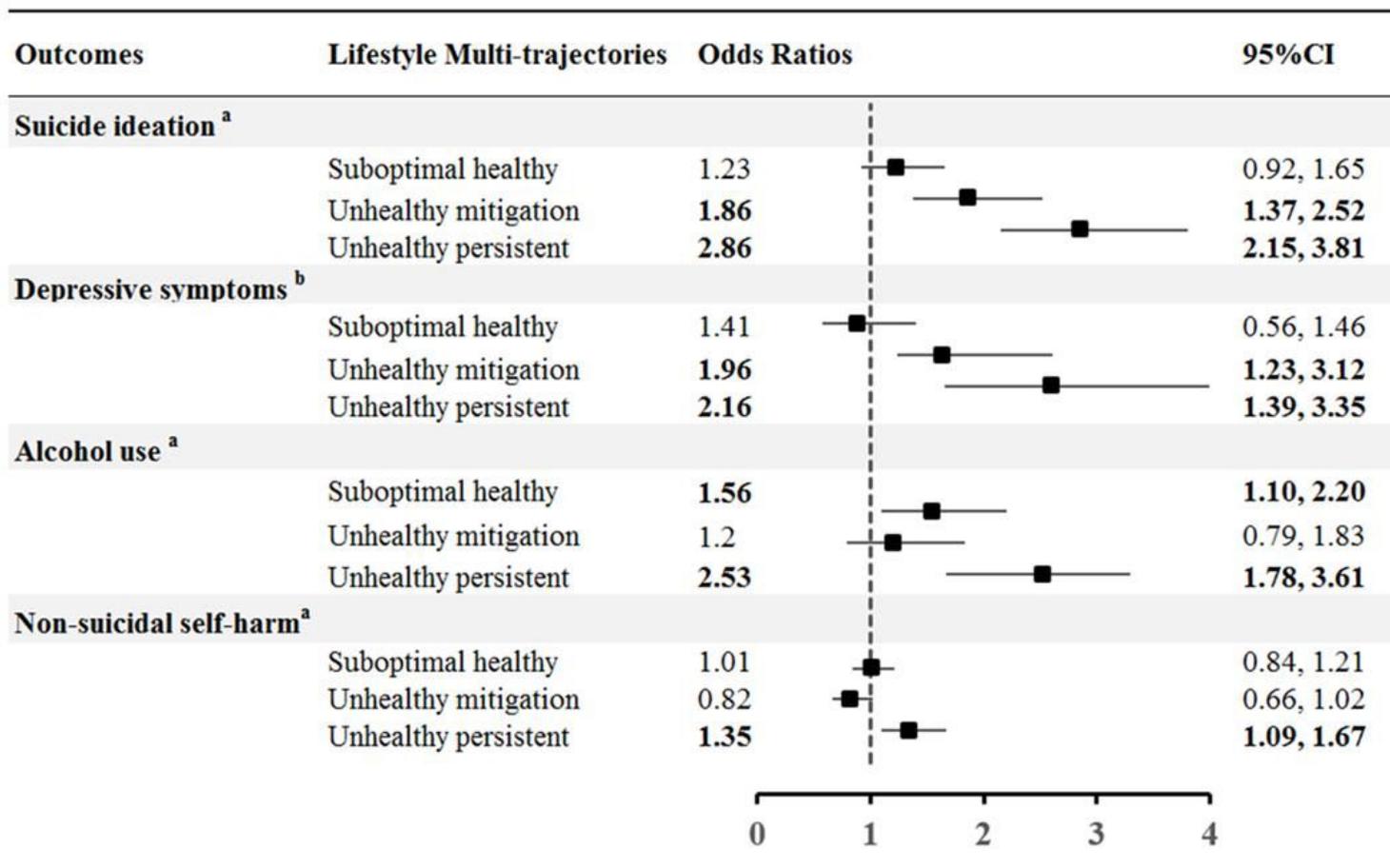
Figure 1

Flowchart of Participants Follow-up



**Figure 2**

Multi-trajectory analysis of lifestyle behaviors among Chinese adolescents in a 5-year longitudinal study



**Figure 3**

Adjusted odds ratios with 95% confidence intervals for suicide ideation, depressive symptoms, alcohol use and non-suicidal self-harm in different lifestyle trajectory groups Bold numbers indicate significant differences when using the healthy group as the reference category; a adjusted for depressive symptoms, age, BMI, sex, family income, parental education, warm parenting and adverse childhood experiences in Wave 4, by using logit regression models. b adjusted for fixed effects of age, BMI, sex, family income, parental education, warm parenting adverse childhood experiences in Wave 4 and random effects of individual and wave, by using mixed effects logistic regression models.

## Supplementary Files

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- [0AppendixTable1.docx](#)
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