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Complete List of Authors:	Yu, Chunyan; Shanghai Institute of Planned Parenthood Research, Department of Epidemiology & Social Science Zhang, Jiashuai; Shanghai Institute of Planned Parenthood Research, Department of Epidemiology & Social Science; Fudan University School of Public Health Zuo, Xiayun; Shanghai Institute of Planned Parenthood Research Lian, Qiguo; Shanghai Institute of Planned Parenthood Research Tu, Xiaowen; Shanghai Institute of Planned Parenthood Research, Dep. of epidemiology & social scinece Lou, Chaohua; Shanghai Institute of Planned Parenthood Research, Department of Epidemiology & Social Science
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Correlations of impulsivity and aggressive behaviors under the general aggression model among adolescent students in Shanghai, China

Chunyan Yu [1†], Jiashuai Zhang [1,2†], Xiayun Zuo[1], Qiguo Lian[1], Xiaowen Tu[1], Chaohua Lou[1*]

1. NHC Key Lab. of Reproduction Regulation (Shanghai Institute of Planned Parenthood Research), Fudan University, Shanghai, PR China.
2. NHC Key Lab. of Reproduction Regulation (Shanghai Institute of Planned Parenthood Research), School of Public Health, Fudan University, Shanghai, PR China.

[†]: Contributed equally.

[*]: Correspondence to: Professor Lou C, Department of Epidemiology and Social Science, Shanghai Institute of Planned Parenthood Research. *Postal Address: 779 Old Hu Min Road, Shanghai 200237, PR China. Email: louchaohua60@163.com. TEL:86 21 64771589.*

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ABSTRACT

Objective: To describe the aggressive behavior, impulsive level of young adolescents in a sample of Chinese middle school students, as well as to explore the relationship between aggressive behavior and impulsivity.

Design: A Computer-Assisted Self-Interview was used to access the correlation of aggressive behavior and impulsivity among young adolescent students. The Barratt Impulsivity Scale was used to measure impulsivity. Aggressive behaviors were determined by self-reports. Chi-square test and binary logistic regression were applied to examine the effect of impulsivity on aggressive behavior.

Setting: Three middle schools located in relatively poor communities of Shanghai.

Participants: Adolescent students from middle schools in grades 7-9.

Results: Totally 1451 students aged 11 to 15 were included in this study (52.01% of boys), and 7.79% of participants reported aggressive behaviors toward others during the past 6 months. Results of logistic regression suggested that high impulsivity is associated with a higher risk of aggressive behavior after adjusting for potential confounders (OR=2.412, 95%CI: 1.427-4.074). Besides, male adolescents with poor family care and poor neighborhood support, being bullied in the past six months, living with brothers or sisters were more likely to behave in aggressive ways.

Conclusions: The present study indicates a positive association between impulsivity and aggressive behavior in Chinese adolescent students. Furthermore, adolescent aggressive behavior was affected by multifaceted factors from individual, family, school, and community. Comprehensive intervention strategies such as controlling the aggressor's impulsivity, helping them better channel their anger, creating a better family, school and neighborhood environment and providing support and services for violence victims are needed.

Keywords: Adolescent students; Impulsivity; Aggressive behavior

Strengths and limitations of this study：

1. The study used a reliable and validated scale to access impulsivity among the participants.
2. The findings warrant further exploration of the factors critical to the understanding of aggressive behaviors.
3. The study may be underpowered to test for specific hypotheses such as the relationship between migrant status and aggressive behavior.
4. The possibility of under-reporting on aggressive behavior and the exclusion of participants because of the absence of key variables may introduce selection bias.

1. Introduction

Aggression is a complex concept and it has traditionally been classified into two distinct subtypes, impulsive or premeditated. The former is characterized by uncontrolled and exaggerated responses to the stimuli which provoke them, while the latter is defined as a planned or conscious aggressive act, not spontaneous or related to an agitated state[1]. Though aggression is one of the basic human traits aiding in the mechanism of survival, there are culturally bounded limits on acceptable levels of aggression or violent behaviors. Those over the limits of acceptable levels are considered harmful[2].

Adolescence is a critical period for curtailing aggressive behaviors, as this developmental window is often accompanied by changes, stresses, and disparities which could arouse the anger[3]. Previous studies have indicated that aggressive behavior was associated with a range of negative outcomes in adolescence, such as the increased risk of depressive symptoms, delinquency, internet addiction, and suicide attempts[4-7]. In the school setting, aggressive behavior was related to low scores in academic performance and higher peer rejection[4, 8]. At the family level, significant relationships were observed between aggressive behavior on the one hand, and family conflict and low family cohesion on the other[4]. More importantly, if aggressive behaviors become prevalent during this stage of development, they can be escalated and persist[3]. Evidence from longitudinal research has demonstrated that adolescents with higher levels of aggression are at greater risk of criminal activity and violence, peer victimization, rule-breaking behaviors, internalizing symptoms, and narcissistic and borderline personality features in the future[9,10]. Furthermore, adolescents with higher aggressiveness tend to have difficulties in controlling waves of anger in adulthood and to have consistently poorer outcomes across domains of life success[11,12]. Also, research has shown that high levels of aggression may result in high social costs because a range of services and resources are needed for the delinquency, incarceration, and unemployment[5,10].

Aggressive behavior in adolescence is a complex phenomenon that cannot be explained by a single factor. The general aggression model (GAM) provides an integrative explanation of aggressive behavior based on three stages[13]: 1) inputs: personal and situational factors; 2) routes or individual internal states: affect, cognition, and arousal; 3) outcomes: decision processes with a (non) aggressive result. In this model, the aggressive acts are influenced by genetic, neuropsychiatric, hormonal, cultural, familial, socioeconomic, and environmental factors. Elements involved in each of the three stages may increase or decrease the probability of behaving aggressively. Thus, identification of these risk factors is critical to the understanding of the aggressive behaviors among adolescents.

In recent years, the role of impulsivity on aggressive behavior has been attracted more and more attention[14]. Aggression among adolescents takes the form of both impulsive and premeditated

behavior[15]. As a personality trait with a strong biological foundation, impulsivity was described as a quick and unplanned response for internal or external stimuli regardless of the negative consequences for an individual or others[16]. Thus, the definition of impulsivity could easily lead us to the intuitive relationship between impulsivity and impulsive aggression. However, researches have shown that impulsivity is present in any type of aggressive act and does not make a distinction between acts of premeditated or impulsive aggression[15,17]. A great number of studies in western countries have demonstrated a positive association between impulsivity and aggression[18-20].

In China, although adolescent impulsivity or aggression has been reported in many studies, researches related to adolescent impulsivity was mainly focused on its relationship with internet addiction and self-injury or suicidal behavior[21-23]. The association between impulsivity and aggressive behavior has been rarely reported. We carried out a school-based cross-sectional study based on the first follow-up of The Global Early Adolescent Study (GEAS) in Shanghai, which is part of a multinational longitudinal cohort study that focused on early adolescents in disadvantaged urban environments. This paper was to examine the relationship between impulsivity and aggressive behaviors under the GAM model among Chinese students aged 11 to 15.

2. Methods

2.1. Study design and participants

Three public primary middle schools in two sub-districts of the Jingan district were selected for the present study. The sites were selected because of ongoing research partnerships and also because they are located in the relatively underdeveloped areas in Shanghai. The criteria for participant selection include: currently studying in grades 7 to 9 (the initial GEAS conducted in grades 6 to 8), aged 11 to 15, living in the geographic division of the study areas, and their parents or guardians consented their participation.

A total of 1578 adolescents were enrolled in the investigation. Among them, 127 (8.05%) were excluded because they were aged over 15 years old or lack of key information. And finally, 1451 eligible students were included in the present study (**Figure 1**).

2.2. Procedure

The data collection was carried out by Computer-Assisted Self-Interview (CASI) using tablets from November to December in 2018. Parental informed consent was collected by head-teachers during parent-teacher meetings. Students who assented to take part in the survey were asked to fill in the electronic questionnaires independently during lunch breaks or psychology courses. If they had any questions, as they did so, they could raise their hands to ask the available investigators. Tablets

were returned after the process and checked by the investigators to ensure that all necessary questions were answered before submission.

It took approximately 30-60 minutes to finish the electronic questionnaire and each student was compensated for their participation with a small gift valuing about 20 CNY.

2.3. Measures

2.3.1. Aggressive behavior

Aggressive behavior in the present study was assessed by two items: 1): During the past 6 months, have you bullied or threatened another boy or girl for any reason? 2): During the past 6 months, have you slapped, hit or otherwise physically hurt another boy or girl in any way that they did not want? Each item comprises six answer options: 1) no; 2) yes, both for girls and boys; 3) yes, for boys; 4) yes, for girls; 5) don't know; 6) refuse to answer. The options 5 to 6 are treated as missing values in data analysis. The participant was considered to be an aggressor if both or one of the two behaviors listed above exists.

2.3.2. Impulsivity and other factors

The impulsivity in the present study was measured by the Barratt Impulsivity Scale (BIS-11), a valid and reliable instrument developed by Barratt in 1959 and was revised by Patton in 1995 [24]. The BIS-11 is one of the most often used tools to assess impulsivity. It is composed of 30 items and the items are grouped into three sub-scales: Attentional impulsivity (AI, 8 items) describes the tendency to inattention or to make a quick decision; Motor impulsivity (MI, 11 items) is about the propensity to act solely on the spur of the moment despite the consequences; Nonplanning impulsivity (NPI, 11 items) indicates the lack of a plan for daily or long-term actions [24]. Items are rated on a 4-point Likert-type scale ranging from 1 "rarely/ never" to 4 "almost always/ always". Among 30 items, eleven of them are inverted because they relate to lower impulsivity. The re-coded responses of items were summed into total scores of the full scale and sub-scales with higher scores signaling greater impulsiveness. Previous studies have demonstrated the high reliability and validity of BIS-11 when used in Chinese children and adolescents[25]. In the present study, we assessed the internal consistency of the three subscales and the total scale. The Cronbach's alpha value was 0.50 for AI, 0.78 for NPI, 0.65 for MI, and 0.81 for the total BIS, respectively. Later, the mean score of impulsivity (MSI) was calculated, which is obtained by dividing the total score of BIS-11 or sub-scales by the number of relevant valid items. Scores were further dichotomized (<=median, >median) using median thresholds of all participants when doing multivariate data analysis.

Demographic and environmental factors considered in the present study include participants' age, gender, ethnicity, religion, family structure, family cares, and neighborhood support, etc.

2.4. Data analysis

The primary target of data analysis was to detect the association between impulsivity and aggressive behaviors (as dependent variables). The analysis began with the comparison of the score of BIS-11 and its sub-scales between aggressors and non-aggressors by the independent sample *t*-test. After that, the Chi-square (χ^2) test was applied to assess the differences in aggressive behavior between two groups with high and low impulsivity. Thirdly, multivariate logistic regression was conducted to assess the associations between impulsivity and aggressive behavior. For the dependent variable, four models were explored: 1) model using MSI in BIS-11 (30 items); 2) model using MSI in Attentional sub-scale (8 items); 3) model using MSI in Motor sub-scale (11 items); 4) model using MSI in Nonplanning sub-scale (11 items). In each model, socio-demographic characteristics (age, gender), as well as related social and environmental factors (such as family cares, neighborhood support, et al), were controlled. The statistical analyses were conducted by Stata SE version 15, the level of significance was set at 0.05 (two-tailed).

2.5. Ethical considerations

The present study was approved by the ethical committee of the Shanghai Institute of Planned Parenthood Research (Approved No. PJ2017-27).

2.6. Patient and public involvement

Young adolescents were invited to test the face validity of the questionnaire in the designing stage. During the survey, all participants were provided with an information sheet about psychosocial resources available to them, as well an option within the survey to indicate interest in supported referrals to services. Adolescents are going to be invited to join the interpretations of the findings and dissemination stages of the study as well.

3. Results

3.1 Background characteristics of participants

A total of 1451 students (51.21% of boys) aged 11 to 15 with a mean age of 13.47 ± 0.96 were included in this study, the proportion of students in grades 7, 8, 9 is 33.29%, 37.08%, and 29.50%, respectively. The background characteristics of eligible participants are described in **Table 1**. More than four-fifths (83.46%) of participants had Hukou of Shanghai, and almost all (92.49%) of them were taken care of primarily by their parents. More than 70% of participants reported that they had no religion, while nearly 20% of them are Buddhist, and the proportion of Christians or Catholics is 5.44%.

Table 1 Basic characteristics of eligible participants

Variables	Frequency (n)	Percent (%)
Age (years)		
11~13	720	49.62
14~15	731	50.38
Gender		
Male	743	51.21
Female	708	48.79
Ethnic group*		
Ethnic Han	1425	98.21
Others	25	1.72
Shanghai Hukou*		
Yes	1211	83.46
No	136	9.37
Primary caregiver*		
Self-care	3	0.19
Parents	1342	92.49
Others	94	6.48
Religion*		
No	1040	71.67
Buddhism	278	19.16
Christianity or catholicism	79	5.44
Islam	9	0.62
Others	19	1.31

*: percentages may not add to 100% due to missing data.

3.2 Score of impulsivities between aggressors and non-aggressors

113 (7.79%) of participants reported that they had ever conducted aggressive behavior in the present study. **Table 2** shows the comparison of the scores of impulsivities between aggressors and non-aggressors. The mean score of BIS-11 in aggressors was 68.47, significantly higher than non-aggressors (60.55, $P < 0.001$). Moreover, the mean score of three sub-scales of BIS-11 in aggressors was also higher than their counterparts (17.98 vs 15.82, 25.23 vs 21.84, 25.38 vs 22.99, respectively), the results of *t*-test indicated that the differences are statistically significant ($P < 0.001$).

Table 2 Score of impulsivities, grouping by aggressive behavior

Style of impulsivity	Aggressive behavior			No aggressive behavior			*P*-value
	n	Mean	S.D	n	Mean	S.D	
Total score of impulsivity	96	68.47	11.41	1220	60.55	9.67	< 0.001
Score of attentional impulsivity	105	17.98	3.55	1290	15.82	3.01	< 0.001

Score of motor impulsivity	105	25.23	5.60	1291	21.84	4.44	< 0.001
Score of nonplanning impulsivity	102	25.38	5.22	1281	22.99	5.08	< 0.001

Note: The analysis excluded those participants if any items in BIS-11 or sub-scales were missing; the differences between the two groups were compared by a two-independent t-test.

3.3 Influence factors of aggressive behavior

In the present study, the Chi-square test and multivariable binary logistic regression model were applied to evaluate the effect of impulsivity on aggressive behavior (**Table 3** and **Table 4**). The results indicate that aggressive behavior was present in 11.61% of students with high impulsivity, which is significantly higher than their counterparts with low impulsivity (3.87%; OR=2.412, 95%CI: 1.427-4.074). Furthermore, all of three sub-types of impulsivity were positively associated with the dependent variable; the results of the multivariate analysis suggested that all components of impulsivity (attentional, motor, non-planning) could significantly increase the risk of aggressive behavior (OR_1=2.270, 95%CI: 1.388-3.711; OR_2=2.454, 95%CI: 1.505-4.002; OR_3=1.830, 95%CI: 1.113-3.007, respectively) **(Table 4)**.

The results of the multivariable analysis also suggested that female adolescents may be less likely to be aggressors compared with their male counterparts (OR: 0.459–0.495). Those who perceived very much care from caregivers were less likely to be aggressors(OR: 0.558–0.580). Having brothers or sisters live together(OR: 1.782–1.907), being bullied within the last six months (OR: 9.062–9.358) may greatly increase the risk of conducting aggressive behaviors. However, adolescents' age, number of close friends showed no significant impact on the dependent variable in this study **(Table 4)**.

Table 3 Percentages of aggressive behavior, grouping by personal variables

Variables	No. of participants (n)	Percent (%)	χ^2	*P*-value
Age (years)				
11~13	720	7.64	0.044	0.834
14~15	731	7.93		
Gender				
Male	743	10.90	20.562	<0.001
Female	708	4.52		
Number of close friends				
0~3	528	7.01		
4~6	449	8.24	0.704	0.703
7~	474	8.23		
Primary caregiver care about you				
Not very	706	10.76	21.156	<0.001
Very	716	4.33		
Have brothers or sisters live together				

Nobody	1143	7.00	3.786	0.052
At least one	299	10.37		
Neighbors will help each other				
Never or seldom	294	12.93	19.391	<0.001
Sometimes	509	7.66		
Always	567	4.59		
Bullied within 6 months				
No	872	1.95	115.53	<0.001
Yes	507	18.15		
Score of impulsivity				
Low	749	3.87	30.683	<0.001
High	689	11.61		
Score of attentional impulsivity				
Low	837	4.18	33.016	<0.001
High	601	12.31		
Score of motor impulsivity				
Low	840	4.40	29.07	<0.001
High	598	12.04		
Score of non-planned impulsivity				
Low	741	5.26	11.714	<0.001
High	697	10.04		

NOTE: The percentages between groups are compared by the Chi-square test.

Table 4 Factors associated with aggressive behavior: results of a multivariable binary logistic regression model

Variables	Model 1		Model 2		Model 3		Model 4	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Age (years)								
11~13	ref		ref		ref		ref	
14~15	0.861	(0.539-1.376)	0.839	(0.524-1.341)	0.878	(0.548-1.405)	0.862	(0.541-1.376)
Gender								
Male	ref		ref		ref		ref	
Female	0.467	(0.285-0.765)	0.495	(0.302-0.812)	0.487	(0.298-0.798)	0.459	(0.280-0.752)
Number of close friends								
0~3	ref		ref		ref		ref	
4~6	1.097	(0.616-1.951)	1.113	(0.625-1.984)	1.118	(0.628-1.991)	1.083	(0.610-1.924)
≥7	1.392	(0.792-2.447)	1.326	(0.757-2.324)	1.307	(0.743-2.299)	1.406	(0.801-2.469)
Primary caregiver cares about you								
Not very	ref		ref		ref		ref	
Very	0.576	(0.346-0.956)	0.58	(0.347-0.965)	0.558	(0.336-0.927)	0.569	(0.343-0.943)
Brothers or sisters living together								
Nobody	ref		ref		ref		ref	
At least one	1.782	(1.067-2.977)	1.907	(1.141-3.188)	1.854	(1.106-3.107)	1.845	(1.106-3.078)
Neighbors will help each other								
Never or seldom	ref		ref		ref		ref	
Sometimes	0.665	(0.385-1.147)	0.69	(0.400-1.191)	0.7	(0.404-1.211)	0.695	(0.404-1.197)
Always	0.448	(0.242-0.828)	0.454	(0.246-0.840)	0.465	(0.251-0.863)	0.451	(0.244-0.834)
Bullied within 6 months								
No	ref		ref		ref		ref	
Yes	9.07	(4.921-16.715)	9.206	(5.00-16.963)	9.062	(4.914-16.710)	9.358	(5.079-17.240)

Score of impulsivity								
Low	ref		ref		ref		ref	
High	2.412	(1.427-4.074)	2.27	(1.388-3.711)	2.454	(1.305-4.002)	1.83	(1.113-3.007)

Note: the impulsivity in models 1, 2, 3, and 4 refers to the total impulsivity, attentional impulsivity, motor impulsivity, non-planning impulsivity, respectively.

4. Discussion

The present study sought to adds to our knowledge of the relationship between impulsivity and aggression in Chinese adolescents by exploring this relationship using the GAM model in a sample of primary/middle school students. Consistent with similar research in other populations[3,18,20], adolescents with higher impulsivity were significantly more likely to perform aggressive behaviors. Furthermore, positive associations were found between all subtypes of impulsivity and aggressive behaviors, demonstrating not only motor impulsivity(acting without thinking) but also attentional (unable to be concentrate) and non-planning (lack of forethought) is highly related to adolescents' aggression.

In neuroimaging studies, personality traits such as impulsivity and aggressiveness have been associated with variations in the structure and function of brain networks that regulate mood, impulse, and behavior[26]. The physiological mechanism of impulsivity was generally considered as an excitatory response produced by the nervous system; when stimulated by internal or external factors, it may give rise to an intense emotional state within a short period and this emotion constitutes the basis for impulsive behavior[16]. On the one hand, an individual can be more decisive and courageous on the spur of impulses in the face of unexpected opportunities or challenges and difficulties. On the other hand, if an individual lacks the cognitive resources necessary to manage impulses, he or she can be driven by desire or anger, which may result in a range of negative outcomes[27]. According to the GAM model, when an adolescent appraises a certain situation as a possible source of menace and pain, he or she can become negatively aroused[13]. In such a situation, adolescents with higher impulsivity often show a deficiency in social adaptation and emotional self-control and empathy; therefore, they may face more difficulties to deal with social situations, and their incapacity to adequately managing their emotions may lead them to behave in aggressive ways [28].

Comparing our prevalence of aggressive behavior with previous studies implemented in Chinese settings, given the range of reported published estimates from 3.27 % among middle-school students in Hubei Province to 19.80% of middle school students in Henan Province[29,30], our results suggested a moderate prevalence estimate of aggressive behavior (7.79%). This variation may partially be explained by various social conditions (e.g. economic status, cultural environment, social security) and sample ascertainment methods in different studies. The lack of standardized definition and

measurement methods for adolescent aggression may also contribute to the variation.

The result of the present study indicated that female adolescents were less likely to involved in aggressive behavior toward others than their male counterparts (OR=0.459–0.495), a similar finding was reported elsewhere[31]. Female students tend to have less physical strength than their male peers and they are always required to be quiet, gentle, and polite under Chinese culture; therefore, these students may less likely to behave in aggressive ways. A previous study has demonstrated that girls were prone to social aggression[32], while this study mainly focuses on physical aggression, and thus the female aggressive behaviors may be under-estimated.

The finding that better family care is negatively related to adolescent aggression (OR: 0.558–0.580) is in line with the family coercion theory, which assumes that positive family interactions contribute to decreasing youth problem behaviors[33]. Poor family care might contribute to adolescent's aggressive behaviors in many ways: such as less monitoring and lack of adults to confide in when anger is triggered because of events and processes in the environment. Further, those adolescents who have grown up with poor family care are more likely to elicit negative responses from their parents as they begin to assert their autonomy and independence. These negative interactions are likely to result in increasingly aversive and coercive processes which could put adolescents at a higher risk of aggression and other behavioral problems[34].

The finding of the present study also indicated that adolescents living with their brothers or sisters were more likely to be aggressors (OR: 1.782–1.907). Generally, because the One-Child Policy of China officially ended until only in late 2015, adolescents in our sample were assumed to be only one child if they were from ordinary families. One possible explanation of our result is that students living with siblings might come from immigrant families as the study sites located in the traditional habitat for migrant populations in Shanghai (to confirm our hypothesis we further compared the proportion of "one-child" among migrants and non-migrants, and found that migrants were 6.4 times more likely to have siblings, see appendix 1). Migrant families tend to have more children, lower incomes and worse household conditions, and they were expected to have more difficulties to obtain relevant resources, supports, and treatments, which were historically identified as risk factors for aggression [35]. Because of the ill-equipped emotional regulation skills in adolescents, those students from immigrant families are more likely to develop a sense of inferiority [36], and thus they might behave in aggressive ways in

certain conditions to win the so-called identity and dignity.

A previous study has demonstrated that social and environmental factors were the principal influences of aggression and that neighborhood support was a significant protective factor against aggression[37]. Our study also indicated that the neighborhood support of the adolescents may significantly decrease their likelihood of aggressive behaviors (OR_1: 0.665-0.700; OR_2: 0.448-0.465). Poor neighborhood environment - characterized by high levels of violence, anger, and disapproval and low warmth and support - has been reported to be associated with an increased risk of behavior problems and delinquency and aggression in adolescents[38]. In contrast, students were likely to feel more supported – and less aggressive - in a neighborhood that provides adequate resources and assistance for youth healthy growth and development, such as after-school programming and recreational spaces[39]. These resources may lead to less aggressive behavior by encouraging social networks and bonding within the neighborhood[37].

Adolescent aggressors tend to have higher levels of life stress than their counterparts without such behaviors[40]. Since the school has become the primary arena for an adolescent, stressors caused by discordant school relationships were common such as peer conflicts or bullying[40]. Consistent with previous research that showed that school-related tensions were significant predictors of aggression[33], our study also suggested that peer's bullying was associated with a higher risk of aggressive behavior (OR: 9.062–9.358). Adolescents with bullying experience are likely to breed a negative intention of hostility and revenge. If the resulting negative emotions are not handled properly, it would cause aggressive behavior once the victim has an opportunity to retaliate. Further, adolescents tend to have a stronger ability to imitate. The bullying or aggression of their schoolmates may set a bad example, and thus they might behave similarly in certain conditions. This finding implies the efforts to reduce youth aggression by providing appropriate supports and services to those students who have already been bullied by his schoolmates or peers.

Naturally, there are limitations to this study. Firstly, because of the cross-sectional design, the results cannot provide firm conclusions regarding the causal effects proposed. Secondly, the aggressive behavior in this study is based on self-reports, which may result in the underestimation of aggression (particularly with social aggression). Besides, we did not distinguish the impulsive aggressive behaviors from premediated aggressive behaviors. Further studies are needed to explore how

impulsivity plays differently in these two forms, given their different biological, psychological, and social etiologic factors as well as management strategies. Finally, more than 8% of enrolled students were excluded because of the absence of dependent variable, although the distribution of basic characteristics between enrolled and excluded subjects was not statistically significant, selection bias may be introduced due to this limitation.

None the less, aggression is part of our makeup. It is human nature to occasionally be aggressive towards someone. Teachers, researchers and health promoters need to tell students that there are times and places where aggression is acceptable. They could also teach adolescents to learn how to channel aggression to the places where it is appropriate and useful. The result of our study does not imply that any single individual trait or factor is to be blamed for being the cause of aggressive and violent behaviors. Instead, we believe that learning what combination of factors contributes to it could point to leads for designing the intervention strategies to help young adolescents. That said, it is important to understand that aggressive and violent behaviors continue to be as much a reality in schools as well as in society at large. Helping young adolescents' learn to control their impulsiveness, channeling the anger, and helping those who are at higher risks of being aggressive could be other approaches to improve all adolescents' physical and psychological well-being rather than only taking disciplinary action against aggressors.

Conclusions

Despite these limitations, the current study provides clear evidence of the role of impulsivity and other factors in aggression in Chinese adolescent students. Consistent with research in other populations, a positive association between impulsivity and aggressive behavior was found. Furthermore, results also indicated that aggressive behavior may be affected by multifaceted factors from individual, family, school and community, suggesting a need for comprehensive intervention strategies such as controlling the aggressor's impulsivity, teaching them to channel their anger, creating a supportive and nurturing school and neighborhood environment as well as providing psychological support and services for violence victims.

Abbreviations

BIS-11: Barratt Impulsivity Scale; CASI: Computer Assisted Self-Interview; GAM: General Aggression Model; GEAS: The Global Early Adolescent Study; MSI: Mean Score of Impulsivity.

Acknowledgments

The Global Early Adolescent Study is a multinational study that aims to understand the development of gender norms in early adolescence, and its impacts on adolescent health across time and geographies. The study operates in conjunction with the World Health Organization (WHO) and the Johns Hopkins Bloomberg School of Public Health (JHBSPH).

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Authors' contributions

Chaohua Lou initiated the GEAS in Shanghai as a coordinator and project leader, all authors are contributed to the study design and data collection. Chunyan Yu and Jiashuai Zhang conducted the data analysis and drafted the paper, all authors are involved in the writing of the manuscript and read and approved the final manuscript.

Declaration of interest

The authors report no conflicts of interest.

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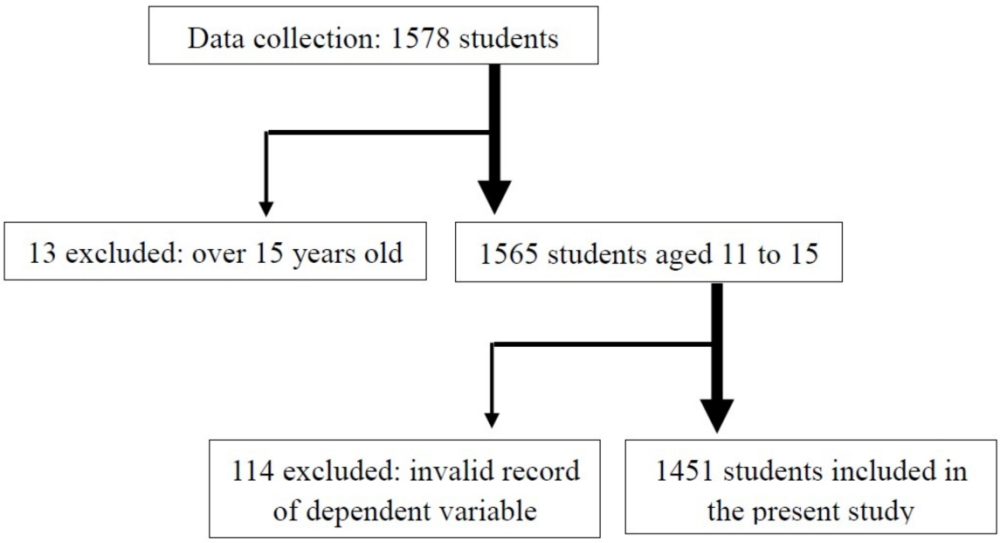

Figure 1: Flow diagram of exclusion and inclusion criteria of participants in data analysis

270x146mm (300 x 300 DPI)

Supplementary file 1:

Table: Differences on distribution of being the only-child between migrant (don't have shanghai Hukou) and non-migrant(have Shanghai Hukou) adolescents

		Only child		χ^2	*P*	*OR*	95%*CI*
		Yes (Exposed)	No (Unexposed)				
Have Shanghai Hukou	Yes (Case)	1028	179	113.2	<0.001	6.38	4.30-9.45
	No (Control)	63	70				

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1

Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	4
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	4
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5

Bias	#9	Describe any efforts to address potential sources of bias	5-6
Study size	#10	Explain how the study size was arrived at	5
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	6
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	6
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	6
Statistical methods	#12c	Explain how missing data were addressed	5-6
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A
Statistical methods	#12e	Describe any sensitivity analyses	N/A
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	4,7
Participants	#13b	Give reasons for non-participation at each stage	4

Participants	#13c	Consider use of a flow diagram	5
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	7
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	7
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	7
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-11
Main results	#16b	Report category boundaries when continuous variables were categorized	8-11
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	21
Discussion			
Key results	#18	Summarise key results with reference to study objectives	12-15

Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14-15
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	12-15
Generalisability	#21	Discuss the generalisability (external validity) of the study results	14
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16-17

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Correlations of impulsivity and aggressive behaviors among adolescents in Shanghai, China: cross-sectional data from Global Early Adolescent Study

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Correlations of impulsivity and aggressive behaviors among adolescents in Shanghai, China: cross-sectional data from Global Early Adolescent Study

Chunyan Yu [1†], Jiashuai Zhang [2†], Xiayun Zuo[1], Qiguo Lian[1], Xiaowen Tu[1], Chaohua Lou[1*]

1. NHC Key Lab. of Reproduction Regulation (Shanghai Institute of Planned Parenthood Research), Fudan University, Shanghai, PR China.
2. NHC Key Lab. of Reproduction Regulation (Shanghai Institute of Planned Parenthood Research), School of Public Health, Fudan University, Shanghai, PR China.

[†]: Contributed equally.

[*]: Correspondence to Professor Lou C, Department of Epidemiology and Social Science, Shanghai Institute of Planned Parenthood Research. *Postal Address: 779 Old Hu Min Road, Shanghai 200237, PR China. Email: louchaohua60@163.com. TEL:86 21 64771589.*

Keywords: Adolescent; Impulsivity; Aggressive behaviors; Neighborhood supports.

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ABSTRACT

Objective: To examine the correlations between impulsivity and aggressive behaviors among Chinese adolescents.

Design: A school-based cross-sectional study.

Setting: Three primary middle schools located in less-developed communities of Shanghai.

Participants: 1524 adolescents aged 11 to 16 years.

Measures: The impulsivity was measured by Barratt Impulsivity Scale (BIS-11), and the aggressive behaviors were determined by self-reports. Data were collected through Computer-Assisted Self-Interview using tablets. Multivariate Firth logistic regression model was conducted to examine correlations between total, attentional, motor, and non-planning impulsivity and aggressive behaviors, respectively

Results: Totally 7.48% of participants reported aggressive behaviors toward others during the past 6 months. The proportion of aggressors among boys and girls was 10.60% and 4.18%, respectively. Results of the multivariate regression suggested the risk of aggressive behaviors was significantly increased among those with the highest tertile of total impulsivity (aOR_{boys}=3.14, 95%CI: 1.48-6.65; aOR_{girls}=3.74, 95%CI: 1.10-12.76) and motor impulsivity (aOR_{boys}=2.91, 95%CI: 1.46-5.82; aOR_{girls}=3.57, 95%CI: 1.25-10.20.), comparing with those with the lowest tertile, for boys and girls, respectively. Besides, younger age, lower social cohesion, and being bullied within 6 months were associated with a higher risk of aggressive behaviors among girls. Less family caring and being bullied within 6 months were associated with the risk among boys.

Conclusions: The present study indicates a positive association between impulsivity and aggressive behaviors, with a more salient correlation between motor impulsivity sub-trait and aggressive behavior among both boys and girls. Furthermore, adolescents' aggressive behaviors were affected by multiple factors from individual, family, peers, and community. Comprehensive intervention strategies such as controlling the aggressor's impulsivity, helping them better channel their anger, creating a better family, school, and neighborhood environment, and providing support and services for violence victims are needed.

Keywords: Adolescent; Impulsivity; Aggressive behaviors; Neighborhood supports.

Strengths and limitations of this study：

1. The study used a reliable and validated scale to access impulsivity among the participants.
2. The findings warrant further exploration of the impulsiveness subscales to the understanding of aggressive behaviors critically.

3. The simplified measurement of aggressive behavior prevents the further distinction of the impulsive aggressive behavior from premediated aggressive behavior. Further studies are needed to explore how different facets of impulsivity plays differently in these two forms.

1. Introduction

Aggression is a complex concept. It has traditionally been classified into two distinct subtypes, impulsive(also known as reactive or hostile) or premeditated (also known as proactive or instrumental). The former is characterized by uncontrolled and exaggerated responses to the stimuli, while the latter is defined as planned or conscious aggressive acts, not spontaneous or related to an agitated state[1]. Though the division is not without meaningfulness to guide the prevention and intervention due to the potential harm it could cause, there were some criticism of the dichotomous method of characterizing aggressive behavior as the distinction of the two is not that clear and it is the harm that should be concerned regardless the typology of the actions [2].

Previous studies have indicated that aggressive behavior was associated with a range of adverse outcomes in adolescence, such as the increased risk of depressive symptoms, delinquency, internet addiction, and suicide attempts[3-6]. In the school setting, aggressive behavior was related to low academic performance scores and higher peer rejection[3, 7]. At the family level, significant relationships were observed between aggressive behavior on the one hand and family conflict and low family cohesion on the other[3]. More importantly, if aggressive behaviors become prevalent during this developmental stage, they can be escalated and persist[8]. Evidence from longitudinal research has demonstrated that adolescents with higher aggression levels are at greater risk of criminal activity and violence, peer victimization, rule-breaking behaviors, internalizing symptoms, and narcissistic and borderline personality features in the future[9, 10]. Furthermore, adolescents with higher aggressiveness tend to have difficulties in controlling waves of anger in adulthood and have consistently poorer outcomes across life success domains [11, 12]. Also, research has shown that high levels of aggression may result in high social costs because a range of services and resources are needed for the delinquency, incarceration, and unemployment[5, 9].

As a personality trait with a strong biological foundation, impulsivity was defined as a quick and unplanned response for internal or external stimuli regardless of the negative consequences for an individual or others[13]. The definition of impulsivity does have overlaps with aggressiveness. It is also one of the main precursors of a set of antisocial behaviors and the basis for several pathological disorders such as attention-deficit/hyperactive disorder, borderline personality disorder and antisocial personality disorder[14-16]. A great number of studies in western countries have demonstrated a positive association between impulsivity and aggression[7, 17-19], both concurrently and longitudinally. However, such correlations were majorly explored among the forensic population or clinical sample, or taking the impulsivity as a whole (using the total impulsive score in the analysis)) instead of considering it as a multi-facet construct.

Among adolescents, studies showed that impulsivity might not be a direct risk for aggression. Youth often cannot adequately manage their emotions when facing difficulties, leading them to behave in aggressive ways [20]. Existing research also argues that behaviors resulting from motor impulsiveness are by nature unplanned or reactive[21]. In contrast, behaviors resulting from attentional (cognitive) impulsiveness are more likely to be planned or proactive. The latter should be taken more attention and in consideration of targeted intervention or treatment[14]. Other researches showed that impulsivity was present in any type of aggressive act and did not distinguish between acts of premeditated or impulsive aggression[16, 22, 23]. Given the mixed results and their relevance to both healthy and harmful facets of the behaviors, the role of impulsivity still attracts numerous attentions. The question of whether a person is capable of modulating their cognition and behavior to fit the demands of a given environment is imperative[14], which makes understanding the role of impulsiveness in the forming of aggression among healthy/ordinary population, especially among young adolescents who are at the critical developing stage urgent.

The present study is guided by Bronfenbrenner's ecological model and Blum's conceptual framework for research targeting early adolescence[24], including family-, school- and neighborhood-factors in the process of shaping youth's aggressive behavior despite individual biological characteristics and personal traits[25]. At the family level, family structure and parental connectedness would help buffer the anger, while school and peer interactions exert significant influences on the conducting of aggressive havior[25, 26]. Neighborhood environment is another important but always neglected factor for shaping aggressive behavior as it provides the scenario for multiple health risk behaviors[27]. For adolescence, specifically, it is a critical period for curtailing aggressive behaviors as both impulsivity and sensation seeking (both relate to risk-taking behaviors)are at their peak during this developmental window according to the Dual System Model[21]. The changes, stresses, and disparities could arouse anger easily[8]. According to Blum's framework[24], adolescence is also a dynamic developmental period of learning and adaptation, which creates both vulnerabilities and unique opportunities for early intervention and prevention. Thus, the identification of risk factors is critical to the understanding of aggressive behaviors among adolescents.

There are also culturally bounded limits on acceptable levels of aggression or violent behaviors. Aggressive behaviors over the boundaries of acceptable levels are often considered harmful[28]. Such cultural differences were noted by researchers both in the level of aggression and their correlations, reflected through the social environment and individual differences, including personality and cognition [23]. In China, researches on adolescents' impulsiveness were mainly focused on its impacts on internet addiction and self-injury or suicidal behavior[29-31], while researches on the association

between impulsivity and aggressive behaviors were scant. We used the wave 2 cross-sectional data from the Global Early Adolescent Study (GEAS) in Shanghai to examine the correlations of impulsivity and aggressive behaviors with the consideration of covariates in the individual, family, school and neighborhood level according to the ecological model. GEAS a multinational longitudinal study that focused on early adolescents in disadvantaged urban environments with a gender lens. For the present study, we hypothesized that (1) impulsivity would be positively correlated with young adolescents' aggressive behavior while the correlation would be strong among motor or non-planning impulsiveness and aggression; (2)Ecological factors like family interactions, peer interactions and community environment would be influential to the forming of adolescents' aggressive behaviors.

2. Methods

2.1. Study design and participants

Data for this study were drawn from wave 2 of the GEAS investigation. A stratified cluster sampling procedure was adopted for the selection of participants in GEAS Shanghai site. Three primary public middle schools in two less-developed sub-districts of the Jing'an district in Shanghai were selected, and the fieldwork was implemented with the coordination of key informants from the local teacher's organization. All eligible students in grades 7th to 9th (the baseline investigation of GEAS was conducted in grades 6th to 8th) were invited to participate in the study after obtaining their assent and the consent of their parents or guardians.

A total of 1611 adolescents participated in the wave 2 investigation. Of them, 87 (5.40%) were excluded because of missing information on impulsivity (16) or aggressive behaviors (71), respectively. Finally, 1524 eligible students were included in the data analysis.

2.2. Procedure

Data were collected through tablets using the Computer-Assisted Self-Interview (CASI) method during November and December in 2018. The students were organized by their teachers in the class units to fill in the electronic questionnaire independently during the lunch break or psychological class. In each class, 1-2 trained investigators were present in case the participants need assistance with the tablet using. Communication or discussion among participants during the process was dissuaded, while questions regarding the survey could be raised to the available investigators. The questionnaire took approximately 25 to 40 minutes to finish. The tablets were returned after the process and checked by the investigators to ensure that all necessary questions were answered before submission. Each student was compensated for their participation with a small gift valued at 20-30 CNY after the process.

The GEAS in Shanghai was approved by the Medical Ethical Committee of the Shanghai Institute

of Planned Parenthood Research (No. PJ2017-27); a deemed exempt for secondary data analysis was approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

2.3. Measures

2.3.1. Aggressive behavior

Aggressive behavior was assessed by two items: 1): During the past 6 months, have you bullied or threatened another boy or girl for any reason? 2): During the past 6 months, have you slapped, hit, or otherwise physically hurt another boy or girl in any way that they did not want? Each item comprised six options: 1) no; 2) yes, both for girls and boys; 3) yes, for boys; 4) yes, for girls; 5) don't know; 6) refuse to answer. Options 5 and 6 were treated as missing values in data analysis. A student was classified into an aggressor if both or one of the two behaviors listed above exists.

2.3.2. Impulsivity

The impulsivity was measured by BIS-11, a valid and reliable instrument developed by Barratt in 1959 and revised by Patton in 1995[32]. The scale composed of 30 items and grouped into three subscales: attentional impulsivity (AI, 8 items) describes the tendency to inattention or to make a quick decision; motor impulsivity (MI, 11 items) is about the propensity to act solely on the spur of the moment despite the consequences; non-planning impulsivity (NPI, 11 items) indicates the lack of a plan for daily or long-term actions[32]. The items were rated by a 4-point Likert-type option from 1 (rarely/ never) to 4 (almost always/ always), and mean scores ranged from 1 to 4 of the scales were calculated after partly items were scored transpose, with a higher score indicating greater impulsiveness. We split the continuous mean scores into tertiles in the multivariate regression model due to skewed distributions of mean scores and the absence of generalized cut-off values across researches. The model compared the highest and middle to the lowest tertiles. Previous studies demonstrated the reliability and validity of BIS-11 when used in Chinese children and adolescents, and the polychoric ordinal alpha value in the present study was 0.62 for AI, 0.81 for NPI, and 0.74 for MI, and 0.89 for the total BIS.

2.3.3 Covariates

Covariates include adolescents' age, binary indicators of gender at the individual level, binary indicators of family structure (only child vs. other), perceived care from the primary caregiver that reflecting family caring at the family level, number of close friends, experiences of being bullied within 6 months at the school level, as well as perceived supports from the neighborhood.

2.4. Data analysis

The data analysis began with describing and comparing aggressive behavior, impulsivity, and covariates between boys and girls. Secondly, the differences of the mean scores of BIS-11 and its

subscales between aggressors and non-aggressors were compared using either *t*-test or *Wilcoxon* test. Thirdly, due to the lower prevalence of aggressors in the present study, the multivariate firth logistic regression model[33] was conducted to assess the association between impulsivity and aggressive behavior among the total sample, as well as boys' and girls', respectively. Four models were explored for each group using total BIS-11 mean core and the mean score of each subscale (AI, MI, and NPI, respectively. In each model, the demographic characteristics, as well as personal and ecological factors listed above were controlled. Before modeling, we first examined the cluster effects on the level of school (level-3) and class (level-2) through multilevel zero-models to determine if the hierarchical structure statistically exists in our data given the cluster obtained by cluster sampling. We found, however, the effects were statistically insignificant both for boys or girls, and thus the general logistic regression model was chosen for data analysis. The statistical analyses were conducted by Stata SE version 15. The level of significance was set α=0.05 at two-tailed.

2.5. Patient and public involvement

Young adolescents were invited to test the face validity of the questionnaire in the designing stage. During the survey, all participants were provided with an information sheet about psychosocial resources available to them and an option within the study to indicate interest in supported referrals to services. Adolescents will be invited to join the interpretations of the findings and dissemination stages of the research as well.

3. Results

3.1 Sample characteristics

The eligible participants in this study were aged 11 to 16 years old, with a mean age of 13.32 ± 0.96. Boys included in the analysis were slightly more than girls (51.38% vs. 48.62%). Table 1 exhibits the variables used in this study by gender. Compared to boys, girls reported fewer experiences of being bullied within 6 months and fewer close friends. Boys scored higher on attentional impulsivity, and lower on non-planning impulsivity. Additionally, gender differences in the proportion of only child, family caring, social cohesion, total impulsivity, and motor impulsivity are statistically insignificant (P >0.05), while the prevalence of aggressive behaviors is higher among boys than among girls (P <0.05).

Table 1 Description of demographic variables, aggressive behaviors, impulsivity, and covariates

Variables	Total (N=1524)	Boys (n=783)	Girls (n=741)
Aggressors (%)	7.48	10.60	4.18 *
Only child (%)	78.74	80.20	77.19

Bulled within 6 month (%)	35.24	39.59	30.23 *
No. of close friends (%)			
0-3	36.35	31.03	41.97 *
4-6	30.71	31.16	20.23
7-	32.94	37.08	27.80
Neighbors caring for each other (%)			
Never or seldom	19.95	20.82	19.03
Sometimes	34.58	33.46	35.76
Always	39.57	39.46	39.68
Perceived care from the primary caregiver (%)			
Lower	48.56	49.04	48.04
Higher	49.51	48.28	50.20
Age (Mean ± SD)	13.32 (0.96)	13.35 (0.98)	13.28 (0.94)
Total impulsivity (Mean ± SD)	2.04 (0.34)	2.05 (0.34)	2.04 (0.33)
Attentional impulsivity (Mean ± SD)	2.00 (0.39)	2.04 (0.41)	1.96 (0.37) &
Motor impulsivity (Mean ± SD)	2.01 (0.42)	2.01 (0.43)	2.00 (0.42)
Non-planning impulsivity (Mean ± SD)	2.11 (0.47)	2.08 (0.47)	2.15 (0.46) $

Note: percentages may not add to 100% due to missing data
*: $p < 0.05$, chi-square test; &: $p < 0.05$, Wilcoxon test; $: $p < 0.05$, two-independent t-test.

3.2 Score of impulsivity between aggressors and non-aggressors

Table 2 shows the comparison of impulsivity between aggressors and non-aggressors by gender. The mean score of BIS-11 in aggressors was 2.27 and 2.32 among boys and girls, respectively, which were significantly higher than their counterparts (P <0.001). Moreover, the scores of AI, MI, and NPI in aggressors were significantly higher than those of non-aggressors for both boys and girls ($P < 0.001$).

Table 2 The score (mean ± SD) of impulsivity, grouping by gender and aggressive behavior

	Boys			Girls		
	Aggressors	Non-aggressors	*P*	Aggressors	Non-aggressors	*P*
Total impulsivity	2.27 (0.36)	2.02 (0.33)	<0.001*	2.32 (0.40)	2.03 (0.33)	<0.001&
AI	2.27 (0.45)	2.02 (0.39)	<0.001*	2.20 (0.46)	1.95(0.36)	0.002&
MI	2.28 (0.51)	1.98 (0.41)	<0.001&	2.33 (0.52)	1.99 (0.40)	<0.001&
NPI	2.26 (0.44)	2.06 (0.46)	<0.001*	2.41 (0.52)	2.14 (0.46)	0.001*

*: two-independent t-test; &: Wilcoxon test

3.3 Factors associated with aggressive behavior

For the total sample, the multivariate logistic regression model results indicated the risk of aggressive behaviors was significantly increased among those with the highest tertile of total impulsivity, AI, MI, and NPI when compared with those among the lowest tertile (Table 3, OR:

1.99~3.23). However, a statistically significant difference was not found among the middle tertile group and the lowest tertile group. Table 4 and Table 5 exhibits the results of gender-stratified data analysis for boys and girls, respectively. Similarly, for total impulsivity and MI(model 1 and model 3), the risk of conducting aggressive behaviors significantly increased in the highest tertile group compared to those in the lowest tertile group. However, for AI and NPI (model 2 and model 4), the risk of conducting aggressive behaviors in the highest or middle tertile group was not statistically increased versus the lowest tertile group.

The results suggested that female adolescents were less likely to be an aggressor (Table 3, OR: 0.43~0.48). For boys, those who reported a higher level of family caring were less likely to be an aggressor (Table 4), whereas such an effect was not significant among girls. On the contrary, older age and higher social cohesion were associated with a lower risk of aggressive behaviors among girls (Table 5), while these effects were not significant among boys. Being bullied within 6 months may significantly increase the risk of aggressive behaviors for both boys and girls. However, the number of close friends, family structure (only child) showed no significant associations with aggressive behaviors in this study (Table 4 and 5).

Table 3 Factors associated with aggressive behaviors among all samples: results of a multivariable binary Firth logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11~13	ref	ref	ref	ref
14~16	0.54 (0.34-0.88)	0.54 (0.33-0.87)	0.51 (0.31-0.83)	0.54 (0.34-0.88)
Gender				
Boys	ref	ref	ref	ref
Girls	0.43 (0.27-0.70)	0.48 (0.29-0.77)	0.45 (0.28-0.73)	0.43 (0.27-0.70)
No. of close friends				
0~3	ref	ref	ref	ref
4~6	1.09 (0.62-1.90)	1.08 (0.62-1.90)	1.10 (0.63-1.94)	1.12 (0.64-1.95)
≥7	1.56 (0.90-2.68)	1.42 (0.83-2.44)	1.46 (0.85-2.52)	1.57 (0.91-2.71)
Perceived care from the primary caregiver				
Lower	ref	ref	ref	ref
Higher	0.58 (0.35-0.94)	0.57 (0.35-0.93)	0.58 (0.35-0.95)	0.56 (0.35-0.92)
Only child				
Yes	ref	ref	ref	ref
No	1.62 (0.99-2.68)	1.62 (0.98-2.65)	1.66 (1.01-2.75)	1.56 (0.95-2.57)
Neighbors caring for each other				
Never or seldom	ref	ref	ref	ref
Sometimes	0.65 (0.38-1.11)	0.69 (0.41-1.18)	0.66 (0.39-1.12)	0.66 (0.39-1.12)
Always	0.46 (0.25-0.83)	0.45 (0.25-0.82)	0.43 (0.23-0.78)	0.45 (0.25-0.82)
Being bullied within 6 months				
No	ref	ref	ref	ref
Yes	7.83 (4.44-13.80)	8.23 (4.67-14.50)	8.15 (4.62-14.39)	8.46 (4.81-14.88)

Impulsivity				
Lowest tertile	ref	ref	ref	ref
Middle tertile	2.02 (0.99-4.11)	1.04 (0.55-1.99)	1.26 (0.67-2.37)	1.29 (0.68-2.45)
Highest tertile	3.23 (1.70-6.16)	1.99 (1.12-3.54)	3.07 (1.72-5.50)	2.04 (1.11-3.72)

Note: the impulsivity in the model 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

Table 4 Factors associated with aggressive behaviors among boys: results of a multivariate binary Firth logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11~13	ref	ref	ref	ref
14~16	0.69 (0.39-1.20)	0.67 (0.38-1.16)	0.65 (0.37-1.13)	0.70 (0.40-1.21)
No. of close friends				
0~3	ref	ref	ref	ref
4~6	1.25 (0.64-2.46)	1.19 (0.60-2.33)	1.25 (0.63-2.46)	1.26 (0.64-2.46)
≥7	1.68 (0.86-3.27)	1.48 (0.77-2.87)	1.54 (0.79-3.02)	1.65 (0.84-3.21)
Perceived care from the primary caregiver				
Lower	ref	ref	ref	ref
Higher	0.49 (0.27-0.88)	0.47 (0.26-0.84)	0.49 (0.27-0.89)	0.48 (0.27-0.87)
Only child				
Yes	ref	ref	ref	ref
No	1.35 (0.72-2.53)	1.40 (0.75-2.62)	1.35 (0.72-2.54)	1.30 (0.69-2.43)
Neighbors caring for each other				
Never or seldom	ref	ref	ref	ref

Sometimes	0.81 (0.42-1.55)	0.87 (0.46-1.67)	0.85 (0.44-1.64)	0.82 (0.43-1.56)
Always	0.59 (0.28-1.21)	0.58 (0.28-1.20)	0.55 (0.27-1.13)	0.55 (0.27-1.13)
Being bullied within 6 months				
No	ref	ref	ref	ref
Yes	6.93 (3.56-13.50)	7.20 (3.70-13.99)	7.17 (3.67-14.01)	7.49 (3.86-14.53)
Impulsivity				
Lowest tertile	ref	ref	ref	ref
Middle tertile	1.86 (0.82-4.22)	0.84 (0.38-1.88)	1.20 (0.57-2.54)	1.41 (0.68-2.91)
Highest tertile	3.14 (1.48-6.65)	1.96 (0.99-3.89)	2.91 (1.46-5.82)	1.82 (0.89-3.72)

Note: the impulsivity in models 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

Table 5 Factors associated with aggressive behavior among girls: results of a multivariate binary Firth logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11~13	ref	ref	Ref	ref
14~16	0.33 (0.12-0.89)	0.34 (0.13-0.89)	0.32 (0.12-0.86)	0.34 (0.13-0.90)
No. of close friends				
0~3	ref	ref	Ref	ref
4~6	0.80 (0.29-2.18)	0.87 (0.32-2.34)	0.92 (0.34-2.50)	0.91 (0.33-2.48)
≥7	1.27 (0.50-3.23)	1.26 (0.50-3.17)	1.26 (0.49-3.24)	1.33 (0.52-3.40)
Perceived care from the primary caregiver				
Lower	ref	ref	Ref	ref
Higher	0.93 (0.39-2.21)	0.93 (0.38-2.26)	0.90 (0.38-2.13)	0.86 (0.37-2.03)
Only child				

Yes	ref	ref	Ref	ref
No	2.15 (0.94-4.92)	2.08 (0.91-4.77)	2.20 (0.94-5.15)	2.00 (0.87-4.58)
Neighbors caring for each other				
Never or seldom	ref	ref	Ref	ref
Sometimes	0.47 (0.19-1.17)	0.47 (0.19-1.16)	0.43 (0.17-1.09)	0.46 (0.19-1.16)
Always	0.30 (0.10-0.86)	0.31 (0.11-0.88)	0.28 (0.10-0.81)	0.32 (0.11-0.92)
Being bullied within 6 months				
No	ref	ref	Ref	ref
Yes	9.65 (3.38-27.55)	10.24 (3.61-29.06)	10.08 (3.53-28.78)	10.09 (3.55-28.65)
Impulsivity				
Lowest tertile	ref	ref	Ref	ref
Middle tertile	2.67 (0.69-10.37)	1.64 (0.56-4.83)	1.38 (0.44-4.32)	1.15 (0.31-4.34)
Highest tertile	3.74 (1.10-12.76)	2.13 (0.73-6.19)	3.57 (1.25-10.20)	2.75 (0.91-8.36)

Note: the impulsivity in the model 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

4. Discussion

The present study sought to adds to our knowledge about the relationship between impulsivity and aggression among adolescents by exploring this relationship in a sample of Chinese primary/middle school students. Positive associations were found between the higher levels of total impulsivity and aggressive behaviors, demonstrating the consistent relationship of impulsivity and aggression [7, 8, 34, 35]. The physiological mechanism of impulsivity was generally considered as an excitatory response produced by the nervous system; when stimulated by internal or external factors, it may give rise to an intense emotional state within a short period. This emotion constitutes the basis for aggressive behavior[13]. On the one hand, an individual with high motor impulsivity can be more decisive and courageous on the spur of impulses in the face of unexpected opportunities or challenges and difficulties. On the other hand, if an individual lacks the cognitive resources necessary to manage impulses (of high attentional impulsivity), they can be driven by desire or anger to conduct aggressive behaviors, resulting in a range of adverse outcomes[36].

Studies among forensic and clinical samples found high impulsiveness in both types of aggression, with no significant difference in total scores measured by BIS[1 22]. Studies in ordinary western people indicated that the non-planning sub-trait of impulsivity was related to impulsive aggression[37]. In our sample, however, the correlation of non-planning impulsivity and aggression is not clearly supported. In the multivariate model of our study, a higher level of motor impulsivity was the only sub-trait that significantly contributed to aggressive behaviors among both boys and girls, suggesting that the aggressive behaviors among Chinese youth are conducted in adolescence majorly because of the act without thinking. Though the effects of attentional and non-planning impulsiveness were not statistically significant, there was a consistent trend in the multivariate model that the risk of conducting aggressive behaviors rose when the impulsive level increased. Our result indicated that it might be the critical window for early intervention during the adolescence period before the sub-trait and related cognitive deficit trigged the harmful behavior.

The finding that better family care is negatively related to adolescent boys' aggression (OR: 0.47~0.49) is in line with the family coercion theory, which assumes that positive family interactions decrease boys' problem behaviors[33]. Insufficient family care might contribute to adolescents' aggressive behaviors in many ways: less monitoring and lack of adults to confide in when anger is

triggered because of events and processes in the environment. Further, those adolescents who have grown up with less family care are more likely to elicit negative responses from their parents as they begin to assert their autonomy and independence. These negative interactions are likely to result in increasingly aversive and coercive processes, putting adolescents at a higher risk of aggression and other behavioral problems[34]. Interestingly, such a finding was only positive among boys. It might be because female students are less likely to behave in aggressive ways physically and are always required to be quiet, gentle, and polite under Chinese culture, which does not distinguish between aggressors and non-aggressors.

A previous study has demonstrated that social and environmental factors were the principal influences of aggression and that neighborhood support was a significant protective factor against attack [37]. Our study also indicated that adolescent girls' neighborhood support may significantly decrease their likelihood of aggressive behaviors (OR:0.28~0.32). Poor neighborhood environment - characterized by high levels of violence, anger, and disapproval and low warmth and support - has been reported to be associated with an increased risk of behavior problems and delinquency and aggression in adolescents[38]. In contrast, students were likely to feel more supported – and less aggressive - in a neighborhood that provides adequate resources and assistance for youth healthy growth and development, such as after-school programming and recreational spaces[39]. These resources may lead to less aggressive behavior by encouraging social networks and bonding within the neighborhood[37].

Adolescent aggressors tend to have higher levels of life stress than their counterparts without such behaviors[40]. Since the school has become the primary arena for an adolescent, stressors caused by discordant school relationships were expected, such as peer conflicts or bullying[40]. Consistent with previous research that school-related tensions were significant predictors of aggression[33], our study also suggested that peer bullying was associated with a higher risk of aggressive behavior (OR: 7.83~8.46). Adolescents with bullying experience are likely to breed a negative intention of hostility and revenge. If the resulting negative emotions are not handled properly, it will cause aggressive behavior once the victim has an opportunity to retaliate. Furthermore, adolescents tend to have a strong ability to imitate. The bullying or aggression of their schoolmates may set a bad example, and thus they might behave similarly in certain conditions. This finding implies the efforts to reduce youth

aggression by providing appropriate support and services to those students who have already been bullied by their schoolmates or peers.

The result of the present study indicated that female adolescents were less likely to be involved in aggressive behavior toward others than their male counterparts (OR: 0.45–0.48). Females tend to have less physical strength than males, thus, they are less likely to resort to violence to solve problems. Previous studies has demonstrated that girls were prone to social aggression[38]. Though this study included verbal and social aggression in the outcome related to bully (see supplement table S1 and S2 for multivariate analysis using bully, and physical attack as outcomes separately), the main focus was still on physical aggression. Thus, the girls' aggressive behaviors may be under-estimated.

We compared the prevalence of aggressive behavior in our study with previous studies implemented in Chinese settings. Given the range of reported published estimates from 3.27 % among middle-school students in Hubei Province to 19.80% of middle school students in Henan Province[39 40], our results suggested a moderate prevalence estimate of aggressive behavior (7.48%). This variation may partially be explained by various social conditions (e.g. economic status, cultural environment, social security) and sample ascertainment methods in different studies. The lack of standardized definition and measurement methods for adolescent aggression may also contribute to the variation. The prevalence of aggressive behavior in our sample is significantly lower than that among either Asian Americans or any other racial/ethnic group (White, Black, Hispanic) in the U.S.., according to the result from the Youth Risk Behavior Surveillance System. Suggesting that cultural factors might work as the modifiers between impulsivity and aggression[41]. A study among Chinese and Canadian adolescents suggested that in Eastern cultures, individuals tend to define themselves in the context of social relationships and group membership. Thus the expression of self-focused emotions is discouraged, and peacefulness is highly valued[42]. However, such a trend might decrease as the age increases or the living environment changes, indicating the necessity to employ a developmental view of behavioral changes when considering the cultural influences.

Naturally, there are limitations to this study. Firstly, the results cannot provide firm conclusions regarding the causal effects proposed because of the cross-sectional design. Secondly, this study's aggressive behaviors were assessed by two self-reported items, which may result in the underestimation of aggression. Besides, we did not distinguish the impulsive aggressive behaviors

from premediated aggressive behaviors. Further studies are needed to explore how each facet of impulsivity plays the role differently in these two forms, given their different biological, psychological, social etiologic factors and management strategies. Lastly, our findings may be affected by selection bias due to missing data. However, given the proportion of the enrolled students excluded in the present study was less than 6%, and we use more robust analytical strategies, the bias was adequately controlled.

Aggression is one of the basic human traits aiding in the mechanism of survival. As part of our makeup, it is human nature to be aggressive towards someone occasionally. Teachers, researchers and health promoters need to tell students that there are times and places where aggression is acceptable. They could also teach adolescents to learn how to channel aggression to the areas where it is appropriate and useful. Our study's result does not imply that any individual trait or factor is to be blamed for being the cause of aggressive and violent behaviors. It is always debatable whether impulsivity signal healthy or unhealthy trends in the evolutionarily adaptive. Instead, we believe that learning what combination of factors contributes to it could point to leads for designing the intervention strategies to help young adolescents. That said, it is essential to understand that aggressive and violent behaviors continue to be as much a reality in schools and society at large. Helping young adolescents learn to control their impulsiveness, channeling the anger, and helping those at higher risks of being aggressive could be approached to improving all adolescents' physical and psychological well-being rather than only taking disciplinary action against aggressors.

Conclusions

Despite the limitations, this study contributes to the growing body of research that tries to delve into the relation between three sub-traits of impulsivity and aggressive behaviors through a sample of Chinese middles school adolescent students. Consistent with research in other populations, a positive association between impulsivity and aggressive behaviors were found. Specifically, such correlation was more salient between motor impulsiveness sub-trait and aggressive behavior among boys and girls. Furthermore, results also indicated that aggressive behaviors were affected by several factors within the ecological model. Comprehensive intervention strategies such as controlling the aggressor's impulsivity, teaching them to channel their anger, creating a supportive and nurturing

school and neighborhood environment as well as providing psychological support and services for violence victims are needed.

Abbreviations

BIS-11: Barratt Impulsivity Scale; CASI: Computer Assisted Self-Interview; AI: attentional impulsivity; MI: motor impulsivity; NPI: non-planning impulsivity; GEAS: The Global Early Adolescent Study.

Acknowledgments

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Authors' contributions

Chaohua Lou initiated the GEAS in Shanghai as a coordinator and project leader. All authors contributed to the study design and data collection. Chunyan Yu and Jiashuai Zhang conducted the data analysis and drafted the paper. All authors are involved in the writing of the manuscript and read and approved the final manuscript.

Declaration of interest

The authors report no conflicts of interest.

Data sharing statement

Data are available upon reasonable request but the approval of institutional review board will be necessary. Please contact the corresponding author for detail.

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Supplements:

Table S1 Factors associated with bullying among all samples: results of a multivariable binary logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11~13	ref	ref	ref	ref
14~16	0.58 (0.33-1.02)	0.59 (0.34-1.02)	0.52 (0.29-0.92)	0.59 (0.34-1.02)
Gender				
Boys	ref	ref	ref	ref
Girls	0.42 (0.23-0.74)	0.46 (0.26-0.82)	0.43 (0.24-0.77)	0.42 (0.23-0.74)
No. of close friends				
0~3	ref	ref	ref	ref
4~6	0.90 (0.47-1.74)	0.90 (0.47-1.74)	0.92 (0.47-1.78)	0.94 (0.49-1.81)
≥7	1.39 (0.74-2.59)	1.26 (0.68-2.33)	1.31 (0.70-2.46)	1.39 (0.75-2.61)
Perceived care from the primary caregiver				
Lower	ref	ref	ref	ref
Higher	0.56 (0.31-1.00)	0.55 (0.31-0.98)	0.57 (0.31-1.03)	0.55 (0.31-0.97)
Only child				
Yes	ref	ref	ref	ref
No	1.59 (0.89-2.84)	1.58 (0.89-2.82)	1.64 (0.91-2.95)	1.52 (0.85-2.71)
Neighbors caring for each other				
Never or seldom	ref	ref	ref	ref
Sometimes	0.53 (0.28-0.99)	0.57 (0.30-1.06)	0.54 (0.28-1.02)	0.54 (0.29-1.02)
Always	0.55 (0.28-1.07)	0.54 (0.28-1.05)	0.51 (0.26-1.00)	0.54 (0.28-1.07)

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Being bullied within 6 months				
No	ref	ref	ref	ref
Yes	7.25 (3.67-14.31)	7.73 (3.91-15.26)	7.58 (3.83-15.01)	7.97 (4.04-15.71)
Impulsivity				
Lowest tertile	ref	ref	ref	ref
Middle tertile	2.30 (0.97-5.44)	1.00 (0.47-2.16)	0.98 (0.44-2.16)	1.06 (0.49-2.27)
Highest tertile	3.62 (1.65-7.94)	1.94 (0.99-3.79)	3.51 (1.78-6.92)	2.04 (1.02-4.08)

Note: the impulsivity in the model 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

Table S2 Factors associated with physical violence among all samples: results of a multivariable binary logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11~13	ref	ref	ref	ref
14~16	0.72 (0.41-1.24)	0.71 (0.41-1.23)	0.69 (0.39-1.20)	0.72 (0.42-1.24)
Gender				
Boys	ref	ref	ref	ref
Girls	0.40 (0.22-0.71)	0.45 (0.25-0.80)	0.42 (0.23-0.75)	0.40 (0.23-0.72)
No. of close friends				
0~3	ref	ref	ref	ref
4~6	1.26 (0.65-2.45)	1.25 (0.65-2.44)	1.26 (0.65-2.46)	1.28 (0.66-2.47)
≥7	1.60 (0.84-3.05)	1.46 (0.77-2.78)	1.48 (0.78-2.83)	1.58 (0.83-3.01)
Perceived care from the primary caregiver				
Lower	ref	ref	ref	ref
Higher	0.68 (0.38-1.19)	0.68 (0.38-1.20)	0.67 (0.38-1.19)	0.66 (0.37-1.15)
Only child				
Yes	ref	ref	ref	ref
No	1.33 (0.72-2.44)	1.32 (0.72-2.42)	1.34 (0.73-2.47)	1.29 (0.71-2.37)
Neighbors caring for each other				
Never or seldom	ref	ref	ref	ref
Sometimes	0.64 (0.34-1.21)	0.68 (0.36-1.28)	0.66 (0.35-1.24)	0.66 (0.35-1.23)
Always	0.57 (0.28-1.13)	0.57 (0.29-1.13)	0.53 (0.27-1.05)	0.54 (0.27-1.08)
Being bullied within 6 months				

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
No	ref	ref	ref	ref
Yes	7.40 (3.74-14.64)	7.77 (3.92-15.36)	7.65 (3.87-15.12)	8.18 (4.15-16.16)
Impulsivity				
Lowest tertile	ref	ref	ref	ref
Middle tertile	2.28 (0.97-5.37)	1.20 (0.54-2.65)	1.51 (0.70-3.24)	1.31 (0.63-2.73)
Highest tertile	3.57 (1.62-7.83)	2.41 (1.19-4.88)	3.13 (1.54-6.34)	1.84 (0.91-3.70)

Note: the impulsivity in the model 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1

Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	4
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	4
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5

Bias	#9	Describe any efforts to address potential sources of bias	5-6
Study size	#10	Explain how the study size was arrived at	5
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	6
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	6
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	6
Statistical methods	#12c	Explain how missing data were addressed	5-6
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A
Statistical methods	#12e	Describe any sensitivity analyses	N/A
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	4,7
Participants	#13b	Give reasons for non-participation at each stage	4

Participants	#13c	Consider use of a flow diagram	5
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	7
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	7
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	7
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-11
Main results	#16b	Report category boundaries when continuous variables were categorized	8-11
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	21
Discussion			
Key results	#18	Summarise key results with reference to study objectives	12-15

Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14-15
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	12-15
Generalisability	#21	Discuss the generalisability (external validity) of the study results	14
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16-17

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Correlations of impulsivity and aggressive behaviors among adolescents in Shanghai, China using bioecological model: cross-sectional data from Global Early Adolescent Study

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Correlations of impulsivity and aggressive behaviors among adolescents in Shanghai, China using bioecological model: cross-sectional data from Global Early Adolescent Study

Chunyan Yu [1†], Jiashuai Zhang [2†], Xiayun Zuo[1], Qiguo Lian[1], Xiaowen Tu[1], Chaohua Lou[1*]

1. NHC Key Lab. of Reproduction Regulation (Shanghai Institute for Biomedical and Pharmaceutical Technologies), Fudan University, Shanghai, PR China.
2. NHC Key Lab. of Reproduction Regulation (Shanghai Institute for Biomedical and Pharmaceutical Technologies), School of Public Health, Fudan University, Shanghai, PR China.

[†]: Contributed equally.

[*]: Correspondence to Professor Lou C, Department of Epidemiology and Social Science, NHC Key Lab. of Reproduction Regulation (Shanghai Institute for Biomedical and Pharmaceutical Technologies). *Postal Address: 779 Old Hu Min Road, Shanghai 200237, PR China. Email: louchaohua60@163.com. TEL:86 21 64771589.*

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ABSTRACT

Objective: To examine the correlations between impulsivity and aggressive behaviors among Chinese adolescents.

Design: A school-based cross-sectional study.

Setting: Three primary middle schools located in less-developed communities of Shanghai.

Participants: 1524 adolescents aged 11 to 16 years.

Measures: The impulsivity was measured by Barratt Impulsivity Scale (BIS-11), and the aggressive behaviors were determined by self-reports. Data were collected through Computer-Assisted Self-Interview using tablets. Multivariate Firth logistic regression model was conducted to examine correlations between total, attentional, motor, and non-planning impulsivity and aggressive behaviors, respectively

Results: Totally 7.48% of participants reported aggressive behaviors toward others during the past 6 months. The proportion of aggressors among boys and girls was 10.60% and 4.18%, respectively. Results of the multivariate regression suggested the risk of aggressive behaviors was significantly increased among those with the highest tertile of total impulsivity (aOR_{boys}=3.14, 95%CI: 1.48-6.65; aOR_{girls}=3.74, 95%CI: 1.10-12.76) and motor impulsivity (aOR_{boys}=2.91, 95%CI: 1.46-5.82; aOR_{girls}=3.57, 95%CI: 1.25-10.20.), comparing with those with the lowest tertile, for boys and girls, respectively. Besides, younger age, lower social cohesion, and being bullied within 6 months were associated with a higher risk of aggressive behaviors among girls. Less family caring and being bullied within 6 months were associated with the risk among boys.

Conclusions: The present study indicates a positive association between impulsivity and aggressive behaviors, with a more salient correlation between motor impulsivity sub-trait and aggressive behavior among both boys and girls. Furthermore, adolescents' aggressive behaviors were affected by multiple factors from individuals, family, peers, and community. Comprehensive intervention strategies such as controlling the aggressor's impulsivity, helping them better channel their anger, creating a better family, school, and neighborhood environment, and providing support and services for violence victims are needed.

Keywords: Adolescent; Impulsivity; Aggressive behaviors; Neighborhood supports.

Strengths and limitations of this study：

1. The study used a reliable and validated scale to access impulsivity among the participants.
2. The findings warrant further exploration of the impulsiveness subscales to the understanding of aggressive behaviors critically.

3. The simplified measurement of aggressive behavior prevents the further distinction of impulsive aggressive behavior from premediated aggressive behavior. Further studies are needed to explore how different facets of impulsivity play the role differently in these two forms.

1. Introduction

Aggression is a complex concept. It has traditionally been classified into two distinct subtypes, impulsive (also known as reactive or hostile) or premeditated (also known as proactive or instrumental). The former is characterized by uncontrolled and exaggerated responses to the stimuli, while the latter is defined as planned or conscious aggressive acts, not spontaneous or related to an agitated state[1]. Though the division is not without meaningfulness to guide the prevention and intervention due to the potential harm it could cause, there were some criticism of the dichotomous method of characterizing aggressive behavior as the distinction of the two is not that clear and it is the harm that should be concerned regardless the typology of the actions [2].

Previous studies have indicated that aggressive behavior was associated with a range of adverse outcomes in adolescence, such as the increased risk of depressive symptoms, delinquency, internet addiction, and suicide attempts[3-6]. In the school setting, aggressive behavior was related to low academic performance scores and higher peer rejection[3, 7]. At the family level, significant relationships were observed between aggressive behavior on the one hand and family conflict and low family cohesion on the other[3]. More importantly, if aggressive behaviors become prevalent during this developmental stage, they can be escalated and persist[8]. Evidence from longitudinal research has demonstrated that adolescents with higher aggression levels are at greater risk of criminal activity and violence, peer victimization, rule-breaking behaviors, internalizing symptoms, and narcissistic and borderline personality features in the future[9, 10]. Furthermore, adolescents with higher aggressiveness tend to have difficulties in controlling waves of anger in adulthood and have consistently poorer outcomes across life success domains [11, 12]. Also, research has shown that high levels of aggression may result in high social costs because a range of services and resources are needed for the delinquency, incarceration, and unemployment[5, 9].

As a personality trait with a strong biological foundation, impulsivity was defined as a quick and unplanned response for internal or external stimuli regardless of the negative consequences for an individual or others[13]. The definition of impulsivity does have overlaps with aggressiveness. It is also one of the main precursors of a set of antisocial behaviors and the basis for several pathological disorders such as attention-deficit/hyperactive disorder, borderline personality disorder and antisocial personality disorder[14-16]. A great number of studies in western countries have demonstrated a positive association between impulsivity and aggression[7, 17-19], both concurrently and longitudinally. However, such correlations were majorly explored among the forensic population or clinical sample, or taking the impulsivity as a whole (using the total impulsive score in the analysis)) instead of considering it as a multi-facet construct.

Among adolescents, studies showed that impulsivity might not be a direct risk for aggression. Youth often cannot adequately manage their emotions when facing difficulties, leading them to behave in aggressive ways [20]. Existing research also argues that behaviors resulting from motor impulsiveness are by nature unplanned or reactive[21]. In contrast, behaviors resulting from attentional (cognitive) impulsiveness are more likely to be planned or proactive. The latter should be taken more attention and in consideration of targeted intervention or treatment[14]. Other research showed that impulsivity was present in any type of aggressive act and did not distinguish between acts of premeditated or impulsive aggression[16, 22, 23]. Given the mixed results and their relevance to both healthy and harmful facets of the behaviors, the role of impulsivity still attracts numerous attentions. The question of whether a person is capable of modulating their cognition and behavior to fit the demands of a given environment is imperative[14], which makes understanding the role of impulsiveness in the forming of aggression among healthy/ordinary population, especially among young adolescents who are at the critical developing stage urgent.

The present study is guided by Bronfenbrenner's bioecological model and Blum's conceptual framework for research targeting early adolescence[24], including family-, school- and neighborhood-factors in the process of shaping youth's aggressive behavior despite individual biological characteristics and personal traits[25]. At the family level, family structure and parental connectedness would help buffer the anger. While in school, peer interactions exert significant influences on the conducting of aggressive behavior[25, 26]. Neighborhood environment is another important but always neglected factor for shaping aggressive behavior as it provides the scenario for multiple health risk behaviors[27]. For adolescence, specifically, it is a critical period for curtailing aggressive behaviors as both impulsivity and sensation seeking (both relate to risk-taking behaviors)are at their peak during this developmental window according to the Dual System Model[21]. The changes, stresses, and disparities could arouse anger easily[8]. According to Blum's framework[24], adolescence is also a dynamic developmental period of learning and adaptation, which creates both vulnerabilities and unique opportunities for early intervention and prevention. Thus, the identification of risk factors is critical to the understanding of aggressive behaviors among adolescents.

There are also culturally bounded limits on acceptable levels of aggression or violent behaviors. Aggressive behaviors over the boundaries of acceptable levels are often considered harmful[28]. Such cultural differences were noted by researchers both in the level of aggression and their correlations, reflected through the social environment and individual differences, including personality and cognition [23]. In China, research on adolescents' impulsiveness were mainly focused on its impacts on internet addiction and self-injury or suicidal behavior[29-31], while research on the association between impulsivity and aggressive behaviors were scant. We used the wave 2 cross-sectional data from the

Global Early Adolescent Study (GEAS) in Shanghai to examine the correlations of impulsivity and aggressive behaviors with the consideration of covariates in the individual, family, school and neighborhood level according to the bioecological model. GEAS is a multinational longitudinal study that focused on early adolescents in disadvantaged urban environments with a gender lens. For the present study, we hypothesized that (1) impulsivity would be positively correlated with young adolescents' aggressive behavior while the correlation would be strong among motor or non-planning impulsiveness and aggression; (2) ecological factors like family interactions, peer interactions and community environment would be influential to the forming of adolescents' aggressive behaviors.

2. Methods

2.1. Study design and participants

Data for this study were drawn from wave 2 of the GEAS investigation. A stratified cluster sampling procedure was adopted for the selection of participants in GEAS Shanghai site. Three primary public middle schools in two less-developed sub-districts of the Jing'an district in Shanghai were selected, and the fieldwork was implemented with the coordination of key informants from the local teacher's organization. All eligible students in grades 7th to 9th (the baseline investigation of GEAS was conducted in grades 6th to 8th) were invited to participate in the study after obtaining their assent and the consent of their parents or guardians.

A total of 1611 adolescents participated in the wave 2 investigation. Of them, 87 (5.40%) were excluded because of missing information on impulsivity (16) or aggressive behaviors (71), respectively. Finally, 1524 eligible students were included in the data analysis.

2.2. Procedure

Data were collected through tablets using the Computer-Assisted Self-Interview (CASI) method during November and December in 2018. The students were organized by their teachers in the class units to fill in the electronic questionnaire independently during the lunch break or psychological class. In each class, 1-2 trained investigators were present in case the participants need assistance with the tablet using. Communication or discussion among participants during the process was dissuaded, while questions regarding the survey could be raised to the available investigators. The questionnaire took approximately 25 to 40 minutes to finish. The tablets were returned after the process and checked by the investigators to ensure that all necessary questions were answered before submission. Each student was compensated for their participation with a small gift valued at 20-30 CNY after the process.

The GEAS in Shanghai was approved by the Medical Ethical Committee of the Shanghai Institute for Biomedical and Pharmaceutical Technologies (Formerly named Shanghai Institute of Planned

Parenthood Research, No. PJ2017-27); a deemed exempt for secondary data analysis was approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

2.3. Measures

2.3.1. Aggressive behavior

Aggressive behavior was assessed by two items: 1): During the past 6 months, have you bullied or threatened another boy or girl for any reason? 2): During the past 6 months, have you slapped, hit, or otherwise physically hurt another boy or girl in any way that they did not want? Each item comprised six options: 1) no; 2) yes, both for girls and boys; 3) yes, for boys; 4) yes, for girls; 5) don't know; 6) refuse to answer. Options 5 and 6 were treated as missing values in data analysis. A student was classified into an aggressor if both or one of the two behaviors listed above exists.

2.3.2. Impulsivity

Impulsivity was measured by BIS-11, a valid and reliable instrument developed by Barratt in 1959 and revised by Patton in 1995[32]. The scale composed of 30 items and grouped into three subscales: attentional impulsivity (AI, 8 items) describes the tendency to inattention or to make a quick decision; motor impulsivity (MI, 11 items) is about the propensity to act solely on the spur of the moment despite the consequences; non-planning impulsivity (NPI, 11 items) indicates the lack of a plan for daily or long-term actions[32]. The items were rated by a 4-point Likert-type option from 1 (rarely/ never) to 4 (almost always/ always). After reversely coded the negatively worded items, we calculated the mean scores of the scales. Higher scores indicated greater impulsiveness. Because of the absence of generalized cut-off values among youth across research, and the interest of us to see the changes of aggressive behaviors with increased levels of impulsivity, we split the continuous mean scores into tertiles in the multivariate regression model (The mean BIS cores of total- and sub- scale for each tertile among boys and girls were exhibited in the supplementary table S1) . The model compared the highest and middle to the lowest tertiles. Previous studies demonstrated the reliability and validity of BIS-11 when used in Chinese children and adolescents, and the polychoric ordinal alpha value in the present study was 0.62 for AI, 0.81 for NPI, and 0.74 for MI, and 0.89 for the total BIS.

2.3.3 Covariates

Covariates include adolescents' age, binary indicators of gender at the individual level, binary indicators of family structure (only child vs. other), perceived care from the primary caregiver that reflecting family caring at the family level, number of close friends, experiences of being bullied within 6 months at the school level, as well as perceived supports from the neighborhood.

2.4. Data analysis

The data analysis began with describing and comparing aggressive behavior, impulsivity, and

covariates between boys and girls. Secondly, the differences of the mean scores of BIS-11 and its subscales between aggressors and non-aggressors were compared using either *t*-test or *Wilcoxon* test. Thirdly, due to the lower prevalence of aggressors in the present study, the multivariate firth logistic regression model[33] was conducted to assess the association between impulsivity and aggressive behavior among the total sample, as well as boys' and girls', respectively. Four models were explored for each group using total BIS-11 mean core and the mean score of each subscale (AI, MI, and NPI, respectively). In each model, the demographic characteristics, as well as personal and bioecological factors listed above were controlled. Before modeling, we first examined the cluster effects on the level of school (level-3) and class (level-2) through multilevel zero-models to determine if the hierarchical structure statistically exists in our data given the cluster obtained by cluster sampling. We found, however, the effects were statistically insignificant both for boys or girls, and thus the general logistic regression model was chosen for data analysis. The statistical analyses were conducted by Stata SE version 15. The level of significance was set α=0.05 at two-tailed.

2.5. Patient and public involvement

Young adolescents were invited to test the face validity of the questionnaire in the designing stage. During the survey, all participants were provided with an information sheet about psychosocial resources available to them and an option within the study to indicate interest in supported referrals to services. Adolescents will be invited to join the interpretations of the findings and dissemination stages of the research as well.

3. Results

3.1 Sample characteristics

The eligible participants in this study were aged 11 to 16 years old, with a mean age of 13.32 ± 0.96. Boys included in the analysis were slightly more than girls (51.38% vs. 48.62%). Table 1 exhibits the variables used in this study by gender. Compared to boys, girls reported fewer experiences of being bullied within 6 months and fewer close friends. Boys scored higher on attentional impulsivity and lower on non-planning impulsivity. Additionally, gender differences in the proportion of only child, family caring, social cohesion, total impulsivity, and motor impulsivity are statistically insignificant (P >0.05), while the prevalence of aggressive behaviors is higher among boys than among girls (P <0.05).

Table 1. Description of demographic variables, aggressive behaviors, impulsivity, and covariates

Variables	Total (N=1524)	Boys (n=783)	Girls (n=741)

Aggressors (%)	7.48	10.60	4.18 *
Only child (%)	78.74	80.20	77.19
Bulled within 6 month (%)	35.24	39.59	30.23 *
No. of close friends (%)			
0-3	36.35	31.03	41.97 *
4-6	30.71	31.16	20.23
7-	32.94	37.08	27.80
Neighbors caring for each other (%)			
Never or seldom	19.95	20.82	19.03
Sometimes	34.58	33.46	35.76
Always	39.57	39.46	39.68
Perceived care from the primary caregiver (%)			
Lower	48.56	49.04	48.04
Higher	49.51	48.28	50.20
Age (Mean ± SD)	13.32 (0.96)	13.35 (0.98)	13.28 (0.94)
Total impulsivity (Mean ± SD)	2.04 (0.34)	2.05 (0.34)	2.04 (0.33)
Attentional impulsivity (Mean ± SD)	2.00 (0.39)	2.04 (0.41)	1.96 (0.37) &
Motor impulsivity (Mean ± SD)	2.01 (0.42)	2.01 (0.43)	2.00 (0.42)
Non-planning impulsivity (Mean ± SD)	2.11 (0.47)	2.08 (0.47)	2.15 (0.46) $

Note: percentages may not add to 100% due to missing data

*: $p < 0.05$, chi-square test; &: $p < 0.05$, Wilcoxon test; $: $p < 0.05$, two-independent t-test.

3.2 Score of impulsivity between aggressors and non-aggressors

Table 2 shows the comparison of impulsivity between aggressors and non-aggressors by gender. The mean score of BIS-11 in aggressors was 2.27 and 2.32 among boys and girls, respectively, significantly higher than their counterparts (P <0.001). Moreover, the scores of AI, MI, and NPI in aggressors were significantly higher than non-aggressors for both boys and girls ($P < 0.001$).

Table 2. The score (mean ± SD) of impulsivity, grouping by gender and aggressive behavior

	Boys			Girls		
	Aggressors	Non-aggressors	*P*	Aggressors	Non-aggressors	*P*
Total impulsivity	2.27 (0.36)	2.02 (0.33)	<0.001*	2.32 (0.40)	2.03 (0.33)	<0.001&
AI	2.27 (0.45)	2.02 (0.39)	<0.001*	2.20 (0.46)	1.95(0.36)	0.002&
MI	2.28 (0.51)	1.98 (0.41)	<0.001&	2.33 (0.52)	1.99 (0.40)	<0.001&
NPI	2.26 (0.44)	2.06 (0.46)	<0.001*	2.41 (0.52)	2.14 (0.46)	0.001*

*: two-independent t-test; &: Wilcoxon test

3.3 Factors associated with aggressive behavior

For the total sample, the multivariate logistic regression model results indicated the risk of aggressive behaviors was significantly increased among those with the highest tertile of total impulsivity, AI, MI, and NPI compared with those among the lowest tertile (Table 3). However, a

statistically significant difference was not found among the middle tertile group and the lowest tertile group. Table 4 and Table 5 exhibits the results of gender-stratified data analysis for boys and girls, respectively. Similarly, for total impulsivity and MI(model 1 and model 3), the risk of conducting aggressive behaviors significantly increased in the highest tertile group compared to those in the lowest tertile group. However, for AI and NPI (model 2 and model 4), the risk of conducting aggressive behaviors in the highest or middle tertile group was not statistically increased versus the lowest tertile group.

The results suggested that female adolescents were less likely to be an aggressor (Table 3). For boys, those who reported a higher level of family caring were less likely to be an aggressor (Table 4), whereas such an effect was not significant among girls. On the contrary, older age and higher social cohesion were associated with a lower risk of aggressive behaviors among girls (Table 5), while these effects were not significant among boys. Being bullied within 6 months may significantly increase the risk of aggressive behaviors for both boys and girls. However, the number of close friends, family structure (only child) showed no significant associations with aggressive behaviors in this study (Table 4 and 5).

Table 3. Factors associated with aggressive behaviors among all samples: results of a multivariable binary Firth logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11-13	ref	ref	ref	ref
14-16	0.54 (0.34-0.88)	0.54 (0.33-0.87)	0.51 (0.31-0.83)	0.54 (0.34-0.88)
Gender				
Boys	ref	ref	ref	ref
Girls	0.43 (0.27-0.70)	0.48 (0.29-0.77)	0.45 (0.28-0.73)	0.43 (0.27-0.70)
No. of close friends				
0-3	ref	ref	ref	ref
4-6	1.09 (0.62-1.90)	1.08 (0.62-1.90)	1.10 (0.64-1.94)	1.12 (0.64-1.95)
≥7	1.56 (0.90-2.68)	1.42 (0.83-2.44)	1.46 (0.85-2.52)	1.57 (0.91-2.71)
Perceived care from the primary caregiver				
Lower	ref	ref	ref	ref
Higher	0.58 (0.35-0.94)	0.57 (0.35-0.93)	0.58 (0.35-0.95)	0.56 (0.35-0.92)
Only child				
Yes	ref	ref	ref	ref
No	1.62 (0.99-2.68)	1.62 (0.98-2.65)	1.66 (1.01-2.75)	1.56 (0.95-2.57)
Neighbors caring for each other				
Never or seldom	ref	ref	ref	ref
Sometimes	0.65 (0.38-1.11)	0.69 (0.41-1.18)	0.66 (0.39-1.12)	0.66 (0.39-1.12)
Always	0.46 (0.25-0.83)	0.45 (0.25-0.82)	0.43 (0.24-0.78)	0.45 (0.25-0.82)
Being bullied within 6 months				
No	ref	ref	ref	ref
Yes	7.83 (4.44-13.80)	8.23 (4.67-14.50)	8.15 (4.62-14.39)	8.46 (4.81-14.88)
Impulsivity				
Lowest tertile	ref	ref	ref	ref

Middle tertile	2.02 (0.99-4.11)	1.04 (0.55-1.99)	1.26 (0.61-2.37)	1.29 (0.68-2.45)
Highest tertile	3.23 (1.70-6.16)	1.99 (1.12-3.54)	3.07 (1.72-5.50)	2.04 (1.11-3.72)

Note: the impulsivity in the model 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

Table 4 Factors associated with aggressive behaviors among boys: results of a multivariate binary Firth logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11-13	ref	ref	ref	ref
14-16	0.69 (0.39-1.20)	0.67 (0.38-1.16)	0.65 (0.37-1.13)	0.70 (0.40-1.21)
No. of close friends				
0-3	ref	ref	ref	ref
4-6	1.25 (0.64-2.46)	1.19 (0.60-2.33)	1.25 (0.63-2.46)	1.26 (0.64-2.46)
≥7	1.68 (0.86-3.27)	1.48 (0.77-2.87)	1.54 (0.79-3.01)	1.65 (0.84-3.21)
Perceived care from the primary caregiver				
Lower	ref	ref	ref	ref
Higher	0.49 (0.27-0.88)	0.47 (0.26-0.84)	0.49 (0.27-0.89)	0.48 (0.27-0.87)
Only child				
Yes	ref	ref	ref	ref
No	1.35 (0.72-2.53)	1.40 (0.75-2.62)	1.35 (0.72-2.54)	1.30 (0.69-2.43)
Neighbors caring for each other				
Never or seldom	ref	ref	ref	ref
Sometimes	0.81 (0.42-1.55)	0.87 (0.46-1.67)	0.85 (0.44-1.64)	0.82 (0.43-1.56)
Always	0.59 (0.28-1.21)	0.58 (0.28-1.20)	0.55 (0.27-1.13)	0.55 (0.27-1.13)
Being bullied within 6 months				
No	ref	ref	ref	ref
Yes	6.93 (3.56-13.50)	7.20 (3.70-13.99)	7.17 (3.67-14.01)	7.49 (3.86-14.53)

Impulsivity				
Lowest tertile	ref	ref	ref	ref
Middle tertile	1.86 (0.82-4.22)	0.84 (0.38-1.88)	1.20 (0.57-2.54)	1.41 (0.68-2.91)
Highest tertile	3.14 (1.48-6.65)	1.96 (0.99-3.89)	2.91 (1.46-5.82)	1.82 (0.89-3.72)

Note: the impulsivity in models 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

Table 5. Factors associated with aggressive behavior among girls: results of a multivariate binary Firth logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11-13	ref	ref	Ref	ref
14-16	0.33 (0.12-0.89)	0.34 (0.13-0.89)	0.32 (0.12-0.86)	0.34 (0.13-0.90)
No. of close friends				
0-3	ref	ref	Ref	ref
4-6	0.80 (0.29-2.18)	0.87 (0.32-2.34)	0.92 (0.34-2.50)	0.91 (0.33-2.48)
≥7	1.27 (0.50-3.23)	1.26 (0.50-3.17)	1.26 (0.49-3.24)	1.33 (0.52-3.40)
Perceived care from the primary caregiver				
Lower	ref	ref	Ref	ref
Higher	0.93 (0.39-2.21)	0.93 (0.38-2.26)	0.90 (0.38-2.13)	0.86 (0.37-2.03)
Only child				
Yes	ref	ref	Ref	ref
No	2.15 (0.94-4.92)	2.08 (0.91-4.77)	2.20 (0.94-5.16)	2.00 (0.87-4.58)
Neighbors caring for each other				
Never or seldom	ref	ref	Ref	ref
Sometimes	0.47 (0.19-1.17)	0.47 (0.19-1.16)	0.43 (0.17-1.08)	0.46 (0.19-1.16)
Always	0.30 (0.10-0.86)	0.31 (0.11-0.88)	0.28 (0.10-0.80)	0.32 (0.11-0.92)
Being bullied within 6 months				

No	ref	ref	Ref	ref
Yes	9.65 (3.38-27.55)	10.24 (3.61-29.06)	10.08 (3.53-28.76)	10.09 (3.55-28.65)
Impulsivity				
Lowest tertile	ref	ref	Ref	ref
Middle tertile	2.67 (0.69-10.37)	1.64 (0.56-4.83)	1.38 (0.44-4.32)	1.15 (0.31-4.34)
Highest tertile	3.74 (1.10-12.76)	2.13 (0.73-6.19)	3.57 (1.25-10.20)	2.75 (0.91-8.36)

Note: the impulsivity in the model 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

4. Discussion

The present study sought to adds to our knowledge about the relationship between impulsivity and aggression among adolescents by exploring this relationship in a sample of Chinese primary/middle school students. Positive associations were found between the higher levels of total impulsivity and aggressive behaviors, demonstrating the consistent relationship between impulsivity and aggression [7, 8, 34, 35]. The physiological mechanism of impulsivity was generally considered as an excitatory response produced by the nervous system; when stimulated by internal or external factors, it may give rise to an intense emotional state within a short period. This emotion constitutes the basis for aggressive behavior[13]. On the one hand, an individual with high motor impulsivity can be more decisive and courageous on the spur of impulses in the face of unexpected opportunities or challenges and difficulties. On the other hand, if an individual lacks the cognitive resources necessary to manage impulses (of high attentional impulsivity), they can be driven by desire or anger to conduct aggressive behaviors, resulting in a range of adverse outcomes[36].

Studies among forensic and clinical samples found high impulsiveness in both types of aggression, with no significant difference in total scores measured by BIS[1 22]. Studies in ordinary western people indicated that the non-planning sub-trait of impulsivity was related to impulsive aggression[37]. In our sample, however, the correlation of non-planning impulsivity and aggression is not clearly supported. In the multivariate model of our study, a higher level of motor impulsivity was the only sub-trait that significantly contributed to aggressive behaviors among both boys and girls, suggesting that the aggressive behaviors among Chinese youth are conducted in adolescence majorly because of the act without thinking. Though the effects of attentional and non-planning impulsiveness were not statistically significant, there was a consistent trend in the multivariate model that the risk of conducting aggressive behaviors rose when the impulsive level increased. Our result indicated that it might be the critical window for early intervention during the adolescence period before the sub-trait and related cognitive deficit trigged the harmful behavior.

Bronfenbrenner's bioecological model supports the finding in our study that better family care was negatively related to adolescent boys' aggression. The result is also in line with the family coercion theory, which assumes that positive family interactions decrease boys' problem behaviors[33]. Insufficient family care might contribute to adolescents' aggressive behaviors in many ways: less

monitoring and lack of adults to confide in when anger is triggered because of events and processes in the environment. Further, those adolescents who have grown up with less family care are more likely to elicit negative responses from their parents as they begin to assert their autonomy and independence. These negative interactions are likely to result in increasingly aversive and coercive processes, putting adolescents at a higher risk of aggression and other behavioral problems[34]. Interestingly, such a finding was only positive among boys. It might be because female students are less likely to behave in aggressive ways physically and are always required to be quiet, gentle, and polite under Chinese culture, which does not distinguish between aggressors and non-aggressors.

A previous study has demonstrated that social and environmental factors were the principal influences of aggression and that neighborhood support was a significant protective factor against attack [37]. Our study also indicated that adolescent girls' neighborhood support might significantly decrease their likelihood of aggressive behaviors. Poor neighborhood environment - characterized by high levels of violence, anger, and disapproval and low warmth and support - has been reported to be associated with an increased risk of behavior problems and delinquency and aggression in adolescents[38]. In contrast, students were likely to feel more supported – and less aggressive - in a neighborhood that provides adequate resources and assistance for youth healthy growth and development, such as after-school programming and recreational spaces[39]. These resources may lead to less aggressive behavior by encouraging social networks and bonding within the neighborhood[37].

Adolescent aggressors tend to have higher levels of life stress than their counterparts without such behaviors[40]. Since the school has become the primary arena for an adolescent, stressors caused by discordant school relationships were expected, such as peer conflicts or bullying[40]. Consistent with the bioecological model as well as the previous research that school-related tensions were significant predictors of aggression[33], our study also suggested that peer bullying was associated with a higher risk of aggressive behavior. Adolescents with bullying experience are likely to breed a negative intention of hostility and revenge. If the resulting negative emotions are not handled properly, it will cause aggressive behavior once the victim has an opportunity to retaliate. Furthermore, adolescents tend to have a strong ability to imitate. The bullying or aggression of their schoolmates may set a bad example, and thus they might behave similarly in certain conditions. This finding implies the efforts to reduce youth aggression by providing appropriate support and services to those students who have already been bullied by their schoolmates or peers.

The result of the present study indicated that female adolescents were less likely to be involved in aggressive behavior toward others than their male counterparts. Females tend to have less physical strength than males; thus, they are less likely to resort to violence to solve problems. Previous studies have demonstrated that girls were prone to social aggression[38]. Though this study included verbal and social aggression in the outcome related to bully (see supplement table S2 and S3 for multivariate analysis using bully and physical attack as outcomes separately), the main focus was still on physical aggression. Thus, the girls' aggressive behaviors may be under-estimated.

We compared the prevalence of aggressive behavior in our study with previous studies implemented in Chinese settings. Given the range of reported published estimates from 3.27 % among middle-school students in Hubei Province to 19.80% of middle school students in Henan Province[39 40], our results suggested a moderate prevalence estimate of aggressive behavior. This variation may partially be explained by various social conditions (e.g., economic status, cultural environment, social security) and sample ascertainment methods in different studies. The lack of standardized definition and measurement methods for adolescent aggression may also contribute to the variation. The prevalence of aggressive behavior in our sample is significantly lower than that among either Asian Americans or any other racial/ethnic group (White, Black, Hispanic) in the U.S., according to the result from the Youth Risk Behavior Surveillance System, suggesting that cultural factors might work as the modifiers between impulsivity and aggression[41]. A study among Chinese and Canadian adolescents suggested that in Eastern cultures, individuals tend to define themselves in the context of social relationships and group membership. Thus the expression of self-focused emotions is discouraged, and peacefulness is highly valued[42]. However, such a trend might decrease as the age increases or the living environment changes, indicating the necessity to employ a developmental view of behavioral changes when considering the cultural influences.

Naturally, there are limitations to this study. Firstly, the results cannot provide firm conclusions regarding the causal effects proposed because of the cross-sectional design. Secondly, this study's aggressive behaviors were assessed by two self-reported items, which may result in the underestimation of aggression. Third, instead of using sum-up scores, we used the tertile to categorize the BIS score in the interest of making better use of existing data. Statistically, it would assume an underlying qualitative difference between the groups, although such assumption may not exist or be replicated by other studies. However, we did calculate the summary score of impulsivities, grouping

by gender and aggressive behavior (supplementary table S4); the result is consistent with what we presented using tertile splits. Besides, we did not distinguish impulsive aggressive behaviors from premediated aggressive behaviors. Further studies are needed to explore how each facet of impulsivity plays the role in these two forms of aggressive behaviors. To better understand their different biological, psychological, social etiologic factors would help with making management strategies. Lastly, our findings may be affected by selection bias due to missing data. However, given the proportion of the enrolled students excluded in the present study was less than 6%, and we use more robust analytical strategies, the bias was adequately controlled.

Aggression is one of the basic human traits aiding in the mechanism of survival. As part of our makeup, it is human nature to be aggressive towards someone occasionally. Teachers, researchers and health promoters need to tell students that there are times and places where aggression is acceptable. They could also teach adolescents to learn how to channel aggression to the areas where it is appropriate and useful. Our study's result does not imply that any individual trait or factor is to be blamed for being the cause of aggressive and violent behaviors. It is always debatable whether impulsivity signal healthy or unhealthy trends in the evolutionarily adaptive. Instead, we believe that learning what combination of factors contributes to it could point to leads for designing the intervention strategies to help young adolescents. That said, it is essential to understand that aggressive and violent behaviors continue to be as much a reality in schools and society at large. Helping young adolescents learn to control their impulsiveness, channeling the anger, and helping those at higher risks of being aggressive could be approached to improving all adolescents' physical and psychological well-being rather than only taking disciplinary action against aggressors.

Conclusions

Despite the limitations, this study contributes to the growing body of research that tries to delve into the relation between three sub-traits of impulsivity and aggressive behaviors through a sample of Chinese middles school adolescent students. Consistent with research in other populations, a positive association between impulsivity and aggressive behaviors were found. Specifically, such correlation was more salient between motor impulsiveness sub-trait and aggressive behavior among boys and girls. Furthermore, results also indicated that aggressive behaviors were affected by several factors within the bioecological model. Comprehensive intervention strategies such as controlling the

aggressor's impulsivity, teaching them to channel their anger, creating a supportive and nurturing school and neighborhood environment as well as providing psychological support and services for violence victims are needed.

Abbreviations

BIS-11: Barratt Impulsivity Scale; CASI: Computer Assisted Self-Interview; AI: attentional impulsivity; MI: motor impulsivity; NPI: non-planning impulsivity; GEAS: The Global Early Adolescent Study.

Acknowledgments

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Authors' contributions

Chaohua Lou initiated the GEAS in Shanghai as a coordinator and project leader. Chaohua Lou and Xiayun Zuo contributed to the study design. Chunyan Yu, Xiayun Zuo, Qiguo Lian, Xiaowen Tu and Chaohua Lou contributed to data collection. Chunyan Yu and Jiashuai Zhang conducted the data

analysis and drafted the paper. All authors are involved in the revising of the manuscript and read and approved the final manuscript.

Declaration of interest

The authors report no conflicts of interest.

Data sharing statement

Data are available upon reasonable request but the approval of institutional review board will be necessary. Please contact the corresponding author for detail.

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Supplementary Tables:

Table S1. Mean scores of impulsivity for each tertile, grouping by gender

	Total impulsivity		AI		MI		NPI	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Lowest tertile	1.71 (0.16)	1.70 (0.17)	1.61 (0.16)	1.60 (0.16)	1.63 (0.17)	1.63 (0.17)	1.61 (0.25)	1.61 (0.25)
Middle tertile	2.05 (0.08)	2.05 (0.08)	2.00 (0.10)	2.01 (0.10)	2.03 (0.10)	2.05 (0.10)	2.14 (0.10)	2.14 (0.10)
Highest tertile	2.43 (0.19)	2.40 (0.20)	2.49 (0.26)	2.44 (0.24)	2.58 (0.30)	2.54 (0.28)	2.61 (0.25)	2.62 (0.24)
Skewness	0.24	0.24	0.45	0.48	0.76	0.64	0.05	-0.05

Table S2. Factors associated with bullying among all samples: results of a multivariable binary logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11~13	ref	ref	ref	ref
14~16	0.58 (0.33-1.02)	0.59 (0.34-1.02)	0.52 (0.29-0.92)	0.59 (0.34-1.02)
Gender				
Boys	ref	ref	ref	ref
Girls	0.42 (0.23-0.74)	0.46 (0.26-0.82)	0.43 (0.24-0.77)	0.42 (0.23-0.74)
No. of close friends				
0~3	ref	ref	ref	ref
4~6	0.90 (0.47-1.74)	0.90 (0.47-1.74)	0.92 (0.47-1.78)	0.94 (0.49-1.81)
≥7	1.39 (0.74-2.59)	1.26 (0.68-2.33)	1.31 (0.70-2.46)	1.39 (0.75-2.61)
Perceived care from the primary caregiver				
Lower	ref	ref	ref	ref
Higher	0.56 (0.31-1.00)	0.55 (0.31-0.98)	0.57 (0.31-1.03)	0.55 (0.31-0.97)

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Only child				
Yes	ref	ref	ref	ref
No	1.59 (0.89-2.84)	1.58 (0.89-2.82)	1.64 (0.91-2.95)	1.52 (0.85-2.71)
Neighbors caring for each other				
Never or seldom	ref	ref	ref	ref
Sometimes	0.53 (0.28-0.99)	0.57 (0.30-1.06)	0.54 (0.28-1.02)	0.54 (0.29-1.02)
Always	0.55 (0.28-1.07)	0.54 (0.28-1.05)	0.51 (0.26-1.00)	0.54 (0.28-1.07)
Being bullied within 6 months				
No	ref	ref	ref	ref
Yes	7.25 (3.67-14.31)	7.73 (3.91-15.26)	7.58 (3.83-15.01)	7.97 (4.04-15.71)
Impulsivity				
Lowest tertile	ref	ref	ref	ref
Middle tertile	2.30 (0.97-5.44)	1.00 (0.47-2.16)	0.98 (0.44-2.16)	1.06 (0.49-2.27)
Highest tertile	3.62 (1.65-7.94)	1.94 (0.99-3.79)	3.51 (1.78-6.92)	2.04 (1.02-4.08)

Note: the impulsivity in the model 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

Table S3. Factors associated with physical violence among all samples: results of a multivariable binary logistic regression model

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age (years)				
11~13	ref	ref	ref	ref
14~16	0.72 (0.41-1.24)	0.71 (0.41-1.23)	0.69 (0.39-1.20)	0.72 (0.42-1.24)
Gender				

Variables	Model 1	Model 2	Model 3	Model 4
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Boys	ref	ref	ref	ref
Girls	0.40 (0.22-0.71)	0.45 (0.25-0.80)	0.42 (0.23-0.75)	0.40 (0.23-0.72)
No. of close friends				
0~3	ref	ref	ref	ref
4~6	1.26 (0.65-2.45)	1.25 (0.65-2.44)	1.26 (0.66-2.46)	1.28 (0.66-2.47)
≥7	1.60 (0.84-3.05)	1.46 (0.77-2.78)	1.48 (0.78-2.83)	1.58 (0.83-3.01)
Perceived care from the primary caregiver				
Lower	ref	ref	ref	ref
Higher	0.68 (0.38-1.19)	0.68 (0.38-1.20)	0.67 (0.38-1.19)	0.66 (0.37-1.15)
Only child				
Yes	ref	ref	ref	ref
No	1.33 (0.72-2.44)	1.32 (0.72-2.42)	1.34 (0.73-2.47)	1.29 (0.71-2.37)
Neighbors caring for each other				
Never or seldom	ref	ref	ref	ref
Sometimes	0.64 (0.34-1.21)	0.68 (0.36-1.28)	0.66 (0.35-1.24)	0.66 (0.35-1.23)
Always	0.57 (0.28-1.13)	0.57 (0.29-1.13)	0.53 (0.27-1.05)	0.54 (0.27-1.08)
Being bullied within 6 months				
No	ref	ref	ref	ref
Yes	7.40 (3.74-14.64)	7.77 (3.92-15.36)	7.65 (3.87-15.15)	8.18 (4.15-16.16)
Impulsivity				
Lowest tertile	ref	ref	ref	ref
Middle tertile	2.28 (0.97-5.37)	1.20 (0.54-2.65)	1.51 (0.70-3.24)	1.31 (0.63-2.73)
Highest tertile	3.57 (1.62-7.83)	2.41 (1.19-4.88)	3.13 (1.54-6.34)	1.84 (0.91-3.70)

Note: the impulsivity in the model 1, 2, 3, and 4 refers to the total, attentional, motor, and non-planning impulsivity, respectively.

Table S4. Summary score (mean ± SD) of impulsivity, grouping by gender and aggressive behavior

	Boys			Girls		
	Aggressors	Non-aggressors	*P*	Aggressors	Non-aggressors	*P*
Total impulsivity	68.07 (11.12)	60.46 (9.77)	<0.001*	69.79 (12.34)	60.84 (9.70)	<0.001&
AI	18.14 (3.65)	16.12 (3.12)	<0.001&	17.76 (3.70)	15.56 (2.88)	0.001&
MI	25.04 (5.46)	21.81 (4.44)	<0.001&	25.70 (5.78)	21.86 (4.45)	<0.001&
NPI	24.99 (4.90)	22.63 (5.14)	<0.001*	26.48 (5.77)	23.49 (5.03)	0.001*

*: two-independent t-test; &: Wilcoxon test

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1

Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	4
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	4
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5

Bias	#9	Describe any efforts to address potential sources of bias	5-6
Study size	#10	Explain how the study size was arrived at	5
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	6
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	6
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	6
Statistical methods	#12c	Explain how missing data were addressed	5-6
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A
Statistical methods	#12e	Describe any sensitivity analyses	N/A
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	4,7
Participants	#13b	Give reasons for non-participation at each stage	4

Participants	#13c	Consider use of a flow diagram	5
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	7
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	7
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	7
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-11
Main results	#16b	Report category boundaries when continuous variables were categorized	8-11
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	21
Discussion			
Key results	#18	Summarise key results with reference to study objectives	12-15

Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14-15
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	12-15
Generalisability	#21	Discuss the generalisability (external validity) of the study results	14
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16-17