

Air Pollution and Prosocial Behavior in Chinese Adolescents: The Role of Resilience and Interpersonal Relations

Yukun Feng^{1,2,*}, Na Ni^{3,*}, Wei Liu⁴, Xinli Chi^{5,6}

¹Shenzhen Audencia Financial Technology Institute, Shenzhen University, Shenzhen, 518060, People's Republic of China; ²Faculty of Business Administration, University of Macau, Macau, People's Republic of China; ³Faculty of Business, Lingnan University, Hong Kong, People's Republic of China; ⁴School of Management, Xiamen University, Xiamen, 361005, People's Republic of China; ⁵School of Psychology, Shenzhen University, Shenzhen, 518060, People's Republic of China; ⁶The Shenzhen Humanities & Social Sciences Key Research Bases of the Center for Mental Health, Shenzhen, 518060, People's Republic of China

*These authors contributed equally to this work

Correspondence: Xinli Chi, School of Psychology, Shenzhen University, Shenzhen, 518060, People's Republic of China, Tel +86 755 26976348, Email xinlich@126.com

Purpose: Past studies have indicated that air pollution is a major environmental factor that negatively affects prosocial behavior in adolescents. However, the mechanism underlying this negative relationship has not been fully explored. This study postulated that this impact may occur through individual resilience, a major psychological capital for adolescents. In addition, we studied interpersonal relations, namely, adolescents' perceived family and teacher support, which may moderate the proposed relationship.

Methods: This study combined the three-year tracking survey data of 11-to-15 old adolescents (N=1301; approximately 48% female) in China with objective data from the air quality index (AQI) to measure the level of air pollution.

Results: Findings from ordinary least squares analysis indicated that air pollution negatively influences adolescents' prosocial behavior, and their resilience mediates this negative relationship. In addition, the results showed that the negative effect of air pollution on adolescent resilience is attenuated by higher family income, whereas it is accentuated by the absence of teacher support.

Conclusion: Our study provides insight into how the negative effect of air pollution on adolescents' prosocial behavior is mediated by their psychological resilience, and highlights the moderating role of adolescents' interpersonal relations in the association between air pollution and their psychological resilience. Our research also provides practical advice on how families, teachers, and psychologists can mitigate this negative impact.

Keywords: psychological resilience, environment, interpersonal relations, prosocial behavior, adolescents, China

Introduction

Adolescents' prosocial behavior, which refers to the voluntary behavior taken by adolescents to benefit others, including activities of sharing, helping, and comforting has attracted the attention of a wide range of scholars.^{1,2} Previous studies have confirmed that prosocial behavior contributes to adolescent development and has significant positive outcomes on both individual and peer aspects.^{3,4} For instance, prosocial behaviors can benefit adolescents by counteracting aggressive behavior, reducing depression and anxiety, improving their academic performance, and gaining social acceptance among peers.^{5,6}

Given these positive effects, some scholars have explored predictors of adolescents' prosocial behavior. For instance, Wentzel et al⁷ developed a theoretical model to summarize that prosocial behavior is influenced by self-processes (such as empathy, depressive affect, perspective-taking, and perceived competence) and contextual cues such as expectations from teachers as well as peers. In contrast, other scholars have investigated the influence of external factors such as parental warmth,⁸ perceived neighborhood social resources,⁹ exposure to prosocial media,¹⁰ and so on. Among these

efforts, the external environment, air pollution in particular, has recently turned out to be one major predictor of adolescents' prosocial behavior.¹¹

Air Pollution and Prosocial Behavior

Air pollution has been widely recognized as an increasingly pivotal factor threatening the mental health of human beings, such as leading to unhappiness,¹² anxiety,¹³ autism,¹⁴ and depression.¹⁵ Moreover, scholars have found that low air quality can cause adverse effects on humans' spill-over behavior. For example, air pollution is associated with a higher risk of high lethality suicide attempts in the population.¹⁶ Likewise, low air quality could increase individual criminal and unethical behavior through the mechanism of anxiety.¹⁷ Additionally, it may inhibit tourists' pro-environmental behavioral intentions, both explicitly and implicitly.¹⁸ Most importantly, adolescent scholars have investigated a similar negative relationship with adolescents' prosocial behavior. For instance, Forns et al¹⁹ found that traffic-related air pollutants are associated with lessened children's prosocial behavior (7–11 years old). Chew et al¹¹ found a similar relationship between a short-term increase in haze and a reduction in students' prosocial behavior using natural laboratory experiments. Nevertheless, these studies do not provide rationales regarding the specific underlying mechanism, leading to our insufficient understanding of such a negative relationship.²⁰ Therefore, this study aims to uncover the explanatory mechanism by postulating that adolescents' psychological resilience mediates air pollution's effect on prosocial behavior.

Air Pollution, Resilience, and Prosocial Behavior

Resilience refers to “the process of, capacity for, or outcome of successful adaptation despite challenging or threatening circumstances”.²¹ A high level of resilience enables individuals to cope with stress and adversity, sustain competence, and recover from high-risk and traumatic situations, ultimately producing positive development outcomes.^{22,23} Previous studies have provided support for our proposed mediation effect of resilience. On the one hand, Masten²⁴ has developed a conceptual model depicting how risks and assets affect such resilience. Notably, the risks refer to factors that lead to a lower level of resilience.²⁵ Previous research highlights that the mental factors and health of individuals are negatively affected by the quality of internal and external environments.^{15,26} Similarly, psychological resilience, which is one of the important psychological factors, is also vulnerable to environmental threats. In particular, our study suggests that air pollution may act as a risk factor to threaten adolescents' resilience. Specifically, air pollutants increase the risk of individuals' perceived stress and psychiatric disorder,²⁷ which may deter individual resilience. For instance, Bonanno et al²⁸ confirmed that the prevalence of resilience is negatively associated with the number of participants' life stressors. Thus, it seems plausible that a higher level of air pollution impedes individuals' resilience by increasing their stress levels. In addition, Flouri et al²⁹ found the relationship between neighborhood green space, one kind of external natural environment, and the construction of children's emotional resilience to risks, which provides further support for our arguments about the influence of the external natural environment on individual psychological resilience.

On the other hand, resilience has been acknowledged to stimulate individual prosocial behavior. Resilient individuals are more open to understanding the emotional needs of others and exhibit greater empathy, which ultimately enhances prosocial behavior.³⁰ Some studies provided empirical support for this positive relationship. For instance, Alessandri et al³¹ found that resilience enables people to control themselves, adjust to external changes, and perform prosocial behavior. Likewise, Xie et al³² reported the highest scores on the measure of prosocial behavior in resilient adolescents. In total, considering the association of resilience with air pollution and prosocial behavior, air pollution may act as a risk factor to decrease the level of resilience, and ultimately causes a low level of prosocial behavior. However, to our knowledge, no research has been conducted to directly investigate the mediating role of resilience in such a relationship. Thus, this study will first explore whether this mediation effect exists.

The Moderating Role of Family Support and Teacher Support

Furthermore, to obtain a full picture of the relationship between air pollution, adolescents' resilience, and their prosocial behaviors, this study explores the contingency mechanism related to the effect of air pollution on resilience. We

investigate the moderating role of interpersonal relations, namely, family support and teacher support received by adolescents.

Adequate family support has been acknowledged as an essential factor that provides adolescents with protective functions insulating them from negative consequences of social or environmental risks.³³ Specifically, parents' educational level and family income contribute to children's cognitive function, mental development, and academic achievement.^{34–36} Previous studies have generally found that adolescents from families of a higher level of parent's education and income are more optimistic and perceive lower stress because these adolescents own fewer social disadvantages.^{37,38} Accordingly, we argue that parents' educational level and family income may attenuate the negative relationship between air pollution and adolescents' resilience, respectively, as they provide adolescents with more resources and enable them to relieve the psychological stress caused by air pollution and thus avoid weakened resilience.

In contrast, the absence of another interpersonal relation of adolescents, teacher support also has a salient effect on the mental development of adolescents.³⁹ Scholars have suggested a positive association between teacher support and adolescents' perceived stress. For example, Östberg et al⁴⁰ found that teacher support could promote students' coping resources to reduce stress. Thus, adolescents who lack such teacher support (such as being overly criticized by the teacher and encountering barriers in communicating with the teacher) are more likely to lack the resources to cope with stress and thus further develop psychological issues. Accordingly, this study argues that the absence of teacher support accentuates the negative relationship between air pollution and resilience. More specifically, the absence of teacher support makes it difficult for adolescents to cope with the stress caused by air pollution and increase the spillover effects of this stress, ultimately exacerbating the negative impact of air pollution on resilience.

To conclude, this study makes an effort to investigate whether (1) the adolescents' psychological resilience mediates the negative relationship between air pollution and adolescents' prosocial behavior; and (2) the moderation effect of parents' educational level, family income, and absence of teacher support on the relationship between air pollution and resilience. Specifically, we propose that parents' educational level and family income attenuate the relationship between air pollution-resilience, respectively. In contrast, the lack of teacher support exacerbates the negative effects of air pollution. We investigate the above arguments by conducting a three-year survey among Chinese adolescents from grades 7 to 9 in Shenzhen, China from 2016 to 2018. [Figure 1](#) demonstrates the conceptual model of our study.

Materials and Methods

Participants

This is a three-year survey study of junior high school students in Shenzhen, China. We randomly selected six out of the city's nine districts and invited one school from each district to participate in the study. We used students' unique student

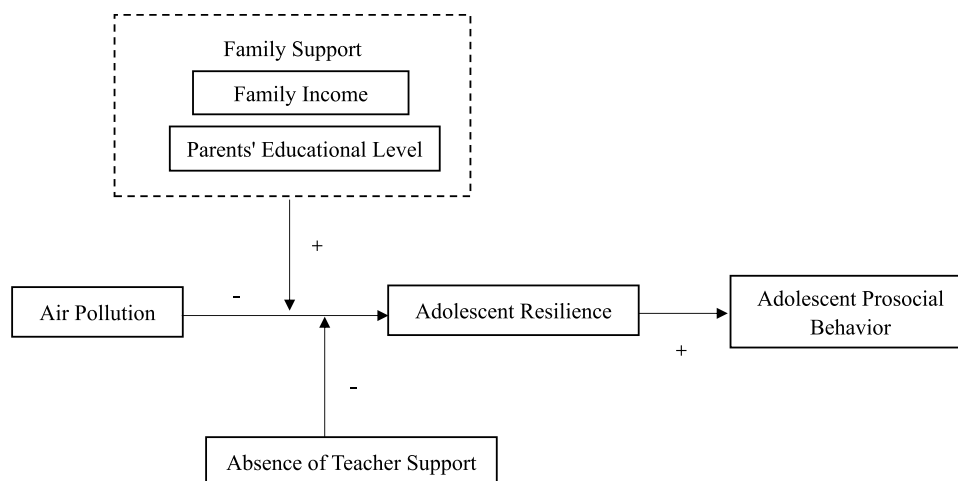


Figure 1 The conceptual model for demonstrating adolescent resilience mediates the negative effects of air pollution on adolescent prosocial behavior, and the moderating effects of family support and lack of teacher support.

numbers as their identification codes. The first wave of the survey was conducted in October 2016, with 1544 Grade 7 students participating, and the average age of participants was 12.46 years old. A year later, we conducted a second wave of the survey with the same group of students in October 2017, with 1511 students completing the questionnaire. Compared to the first wave, 33 students did not take part in this round of the survey. After the same interval of one year, we collected a third wave of data from the same group of students in October 2018, with a total of 1301 students participating in this wave. Compared to the second wave of surveys, 210 students did not participate in the third wave. Overall, a total of 1301 students participated in all three waves of the survey. As this study expected to adopt three consecutive years of survey data to validate the research questions, the 1301 students who participated in all three surveys were chosen as the research sample. In addition, the comparison of participating and nonparticipating students indicated no significant difference in terms of gender and family structure, suggesting that there was no response bias in this study.

Procedure

Before starting the survey, we obtained prior consent from the school, parents, and students in the sample group. During the process of the survey, each student used their own unique student number as the identification code and completed a paper questionnaire that included questions about personal demographic characteristics, family background, resilience, prosocial behavior, and absence of teacher support. Two psychology graduate students participated in the whole process to answer the questions raised by the adolescents. This study and data collection were approved by the administrative committees of the surveyed schools and the human research ethics committee of the affiliated university on June 22, 2016.

Measures

Prosocial Behavior

Adolescents' prosocial behavior was measured by three items from the Chinese Positive Youth Development Scale developed by Shek et al.⁴¹ The original measurement adopted a six-point scale (1 = "Strongly disagree", 6 = "Strongly agree"). For example, "I care about unfortunate people in the society", "I will try my best to contribute to my school or the society" and "I will participate in the voluntary work". The average score of these three items reflects the level of adolescents' prosocial behavior, while higher scores indicate a higher level of prosocial behavior. The average value of Cronbach's alpha of the three waves was 0.761. Overall, the scale showed acceptable reliability.

Air Pollution

We used the Air Quality Index (AQI) to measure the level of air pollution, which has received widespread attention from the public and government. The AQI is widely used and recognized by scholars in the research fields of environmental science and economics.^{42,43} In China, the AQI is calculated based on the pollution degree of each pollutant (see [Appendix 1](#)), and the value range is 0 to 500. The higher the AQI value, the more serious the air pollution. We calculated the air quality information from a database generated by China's National Environmental Monitoring Center by tracking the hourly air quality of 1400 environmental monitoring stations in China. Among them, Shenzhen has 11 air quality monitoring stations. In particular, as adolescents' exposure to air mainly occurs in schools, we selected the nearest monitoring site to the school based on its geographic location information. The hourly air quality data of the previous month were then aggregated into monthly ones. The data were centralized and denoted as AQI before being used for the empirical analysis.

Resilience

Adolescent resilience was measured as a dimension from the Chinese Positive Youth Development scale compiled by Shek et al.,⁴¹ which has three items (such as "When I face difficulty, I will not give up easily"). All items were rated on a six-point scale (1 = "Strongly disagree", 6 = "Strongly agree"). A higher mean score represents higher resilience. The scale showed acceptable reliability; the average value of Cronbach's alpha for adolescent resilience of the three waves was 0.815.

Family Income

Family income was assessed by the average monthly income of the respondents' families over the past year. Family income is a dummy variable that equals one if the family's average monthly income is larger than the median value of the final sample and zeroes otherwise.

Parents' Educational Level

Parents' educational level was measured by the sum score of the educational level of both parents. It is a dummy variable that equals one if the value is larger than the median value of the final sample and zeroes otherwise.

Absence of Teacher Support

This study adopted the absence of teacher support as the school-level moderator, which was measured by the Chinese adolescents' risk behaviors scale developed by Bai.⁴⁴ It contains four items, such as "I was criticized by the teacher without any reason, and it rankled in my heart" and "I find it difficult to communicate with teachers". Adolescents were asked to rate these items using a five-point scale (1 = "never", 2 = "few", 3 = "sometimes", 4 = "often", 5 = "always"). The average score indicates the level of absence of teacher support, with higher scores representing more absence of teacher support. The scale showed acceptable reliability; the average value of Cronbach's alpha of the three waves was 0.708.

Control Variables

We also controlled for the socio-demographic characteristics of the surveyed adolescents, which may influence their prosocial behavior during the data analysis. Such questions included gender (0 = "Male", 1 = "Female"), birthplace (0 = "Village", 1 = "Shenzhen City", 2 = "Other City"), only child or not (0 = "Yes", 1 = "No"), and family structure (0 = "Complete", 1 = "Divorced", 2 = "Single-parent family", 3 = "Others"). In addition, adolescents' depression was controlled, which may have an impact on their prosocial behavior.⁴⁵ We assessed students' depression symptoms using the Chinese adolescents' risk behaviors scale developed by Bai.⁴⁴ The original scale includes nine items on a five-point Likert scale, such as "I do not feel happy" and "The study competition is so fierce that it makes me very bored." Higher scores indicate more serious depression symptoms. Moreover, as the population density may influence the youth's social-related behavior,⁴⁶ we also controlled for the population density of the district where the sample school is located (10,000 people/km²).

Statistical Analysis

This study first conducted descriptive statistics, then we followed Baron and Kenny's (1986)⁴⁷ method to examine the mediation effect of resilience on the relationship between air pollution and prosocial behavior. Finally, this study used ordinary least squares (OLS) to test the moderation effect of family-level and school-level factors, respectively. During the process of analysis, this study controlled individual characteristics factors, including adolescents' gender, birthplace, family structure, only one child or not in their family, and the degree of depression. In addition, we also controlled the environmental conditions such as the population density of each district where the sample is located. We adopted STATA 15.1 to verify our arguments.

Results

Descriptive Analyses

Table 1 showed the descriptive statistics of our paper. We included 3903 samples of 1301 students. The average value of prosocial behavior was 4.97. It shows a high level of prosocial behavior among the sample students. The average score of resilience was 5.1295, ranging from 1 to 6. The average degree of air pollution was 38.6453, indicating that the air quality of Shenzhen was at a relatively good level when compared with other cities in China.

As for the moderators, the average score of family income was 0.4927, indicating that 49.27% of participants had a monthly household income higher than the median of the total sample. The average score of parents' educational level showed that only 36.2% of adolescents had parents with a higher educational level than the median. In addition, the average absence of teacher support was 1.9068.

Table 1 Descriptive Statistical Analysis

Variable	N	Mean	sd	Min	p50	Max
1. Prosocial behavior	3903	4.97	0.9569	1	5	6
2. Resilience	3903	5.1295	0.914	1	5.3333	6
3. Air pollution	3903	38.6453	3.887	33.9415	37.8642	47.4068
4. Family income	3903	0.4927	0.5	0	0	1
5. Parents' education level	3903	0.362	0.4806	0	0	1
6. Absence of teacher support	3903	1.9068	0.8327	0.75	1.75	5
7. Gender	3903	0.4827	0.4998	0	0	1
8. Birthplace	3903	1.011	0.5043	0	1	2
9. One_Child	3903	0.6149	0.4867	0	1	1
10. Family structure	3903	0.0943	0.416	0	0	3
11. Depression	3903	14.7774	6.0029	7	13	40
12. Population Density	3903	0.6174	0.4015	0.2453	0.3239	1.3205

For the control variables, 48.27% were girls. The average score of the birthplace index was 1.011, indicating that most students were born in cities. Meanwhile, 61.49% of the students were non-only children. Table 1 showed that most students have a complete family (mean = 0.0943). On average, students had few depression symptoms (mean = 14.7774). In addition, the average score of population density was 0.6174.

Testing for the Mediation Effect

Following Baron et al,⁴⁷ we tested the mediation effect of adolescent resilience on the relationship between air pollution and adolescents' prosocial behavior through three steps. Table 2 showed the result of the mediation effect. In step 1, we took prosocial behavior as a dependent variable and air pollution as the independent variable. We found that the coefficient of air pollution to prosocial behavior was -0.0163 and maintained a significance level of 1%. This result showed that air pollution negatively influences the students' prosocial behavior. In step 2, we tested the influence of air pollution on adolescent resilience and found that the coefficient of air pollution on resilience was -0.0184 , which was significantly lower than the 1% level. The result illustrated the negative relationship between air pollution and adolescent resilience. In step 3, we put both air pollution and resilience into the regression model with prosocial behavior as the dependent variable. The results showed that the coefficient of air pollution to adolescents' prosocial behavior was -0.0078 and non-significant. In contrast, adolescent resilience was significantly related to adolescents' prosocial behavior ($coef = 0.4608$). Above all, the empirical results showed that resilience played a complete intermediary role in the relationship between air pollution and prosocial behavior, which supports the research arguments of this paper. In

Table 2 Results of the Mediation Effect

Variables	Coef.	SE	T-value	P-value	95% Conf. Interval	Adj-R ²
Step 1						
Prosocial behavior						
Air pollution	-0.0163	0.0049	-3.29	0.001	[-0.0260 -0.0066]	0.1288
Step 2						
Resilience						
Air pollution	-0.0184	0.0045	-4.08	0.000	[-0.0273 -0.0096]	0.2053
Step 3						
Prosocial behavior						
Air pollution	-0.0078	0.0045	-1.73	0.083	[-0.0166 0.0010]	0.2826
Resilience	0.4608	0.0159	28.92	0.000	[0.4296 0.4921]	

addition, our study further tested whether gender differences and age differences affect the mediating effect. Through our analysis, we found that the mediation effect remained largely constant across gender and age.

Testing for the Moderation Effect

We further examined the moderating effects of family and school support on adolescent resilience by running ordinary least squares (OLS) analyses. The results are listed in Table 3-5. In Table 3, the coefficient of Air pollution*Family income was 0.0194 and significantly lower than the 1% level, indicating that family income attenuated the negative role of air pollution on resilience. However, Table 4 showed that the coefficient of Air pollution*Parents' educational level was 0.0069 (p -value = 0.382) with non-significant. Therefore, although the coefficient direction of the impact of parents' educational level was as expected, it had no obvious moderating impact on the relationship between air pollution and resilience. In contrast, the coefficient of Air pollution*Absence of teacher support was -0.0099 and was significant at the 5% level (see Table 5). This result supported our argument that the absence of teacher support amplified the negative effect of air pollution on adolescent resilience. Furthermore, we further analyzed whether the moderating effects of family income and the absence of teacher support were affected by age and gender differences. We found that the original results remained mostly unchanged, except for a non-significant moderating effect of family income in the older age group, and a non-significant moderating effect of the absence of teacher support in the older age group and in the girls' group.

Figures 2 and 3 further show such moderating effects of family and school support. Specifically, when students were from high-income families, the adverse impact of air pollution on adolescent resilience was lessened. In contrast, if students did not perceive support from teachers, the negative effect of air pollution on resilience was strengthened. In other words, family and school support were important factors that affect the adverse effect of air pollution on adolescents' resilience and subsequent adolescents' prosocial behavior.

Table 3 Results of the Moderating Effect of Family Income on the Relationship Between Air Pollution and Adolescent Resilience

Resilience	Coef.	SE	T-value	P-value	95% Conf. Interval
Air pollution	-0.0293	0.0060	-4.85	0.000	[-0.0411 -0.0175]
Family income	-0.7391	0.2781	-2.66	0.008	[-1.2844 -0.1939]
Air pollution*Family income	0.0194	0.0072	2.7	0.007	[0.0053 0.0335]
N	3903	Adj-R ²	0.2063		

Table 4 Results of the Moderating Effect of Parents' Educational Level on the Relationship Between Air Pollution and Adolescent Resilience

Resilience	Coef.	SE	T-value	P-value	95% Conf. Interval
Air pollution	-0.0206	0.0057	-3.6	0.000	[-0.0318 -0.0094]
Parents' educational level	-0.3068	0.3142	-0.98	0.329	[-0.9228 0.3092]
Air pollution* Parents' educational level	0.0069	0.0079	0.87	0.382	[-0.0085 0.0223]
N	3903	Adj-R ²	0.2052		

Table 5 Results of the Moderating Effect of the Absence of Teacher Support on the Relationship Between Air Pollution and Adolescent Resilience

Resilience	Coef.	SE	T-value	P-value	95% Conf. Interval
Air pollution	0.0021	0.0088	0.23	0.816	[-0.0153 0.0194]
Absence of teacher support	0.2849	0.1551	1.84	0.066	[-0.0191 0.5889]
Air pollution* Absence of teacher support	-0.0099	0.0040	-2.51	0.012	[-0.0177 -0.0022]
N	3903	Adj-R ²	0.2106		

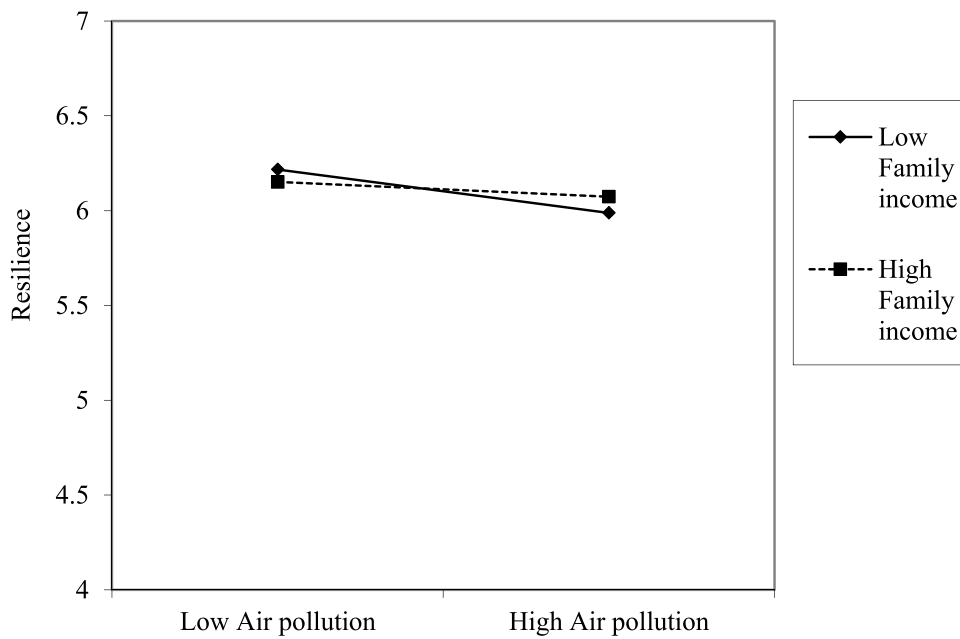


Figure 2 Interactive effects of family income and air pollution on adolescent resilience.

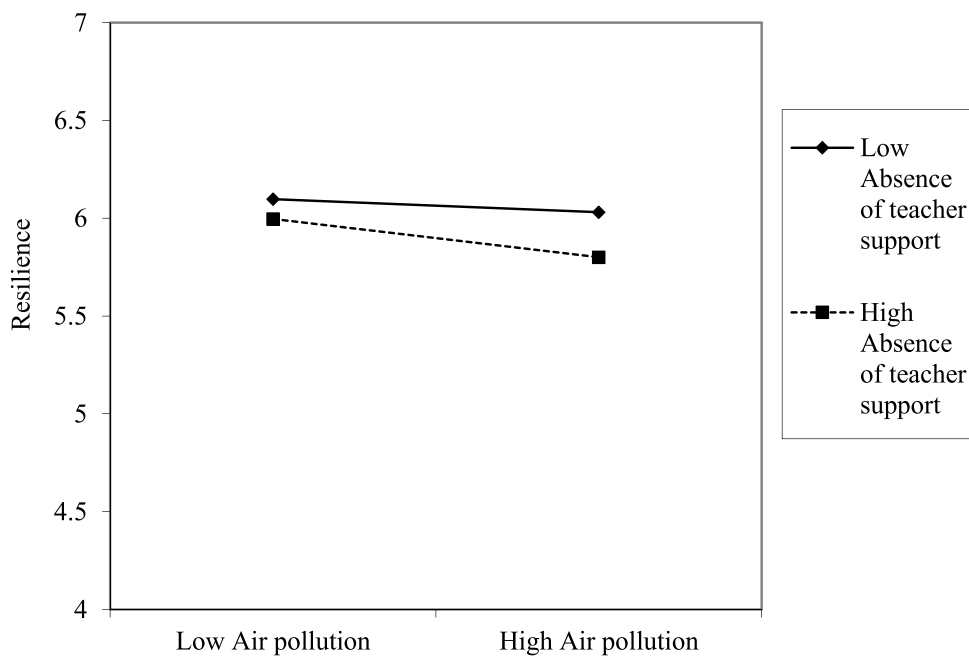


Figure 3 Interactive effects of the absence of teacher support and air pollution on adolescent resilience.

Discussion

Recent studies have shed light on the adverse effect of air pollution on children and adolescents prosocial behavior,¹¹ yet relatively limited attention has been paid to the mechanism through which air pollution influences prosocial behavior. To fill this research limitation, we used a three-year study of 1301 adolescents in Shenzhen and found that resilience is a key mediating mechanism between air pollution and prosocial behavior among adolescents. In addition, the negative effect of air pollution on adolescent resilience is attenuated by higher family income and accentuated by the absence of teacher support. Overall, it

indicates that air pollution decreases adolescents' psychological capital and positive spillover behavior. It further emphasizes the essential role that both parents and schools play in eliminating this negative effect.

Theoretical Contributions

This study contributes to theory and practice in several aspects. First, we extend the research on the negative influence of the physical environment on adolescents' prosocial behavior by exploring the mediating role of individual resilience.¹⁹ Our results show that resilience may transmit the effect of air pollution on individuals' prosocial behavior. Specifically, this study identifies air pollution as a risk factor²⁴ that threatens individual resilience by increasing their perceived stress.²⁸ Consequently, weakened individual resilience may make adolescents less likely to empathize with others and control conflict.^{30,31} As a result, decreasing resilience influenced by air pollution would further reduce adolescents' engagement in prosocial behavior.

Second, this paper articulates that support from family and school functions as boundary conditions of the relationship between air pollution and resilience. Adequate economic resources of a family may enable their children to resist the stress caused by air pollution and avoid the damage to psychological resilience and subsequent behavior. Our finding echoes the arguments of scholars by highlighting that adequate family or social support improves an individual's mental health by strengthening personal resilience, thereby further avoiding negative personal behavior.⁴⁸ Nevertheless, we did not find the moderating effect of parents' educational level on the relationship between air pollution and resilience. We suspect that it may be more instrumental in promoting children's academic achievement motivation.⁴⁹ In contrast, the interaction between the absence of teacher support and air pollution poses a threat to adolescent resilience. This finding supports previous research that highlights the important role of teachers in promoting students' psychological and behavioral development.³⁹ For example, teachers can enhance students' resilience and prosocial behavior through professional educational approaches such as the Teaching Personal and Social Responsibility model.⁵⁰ Similarly, the ERS-AE-Stress-Prosocial (ESPS) structured intervention has also been shown to have a beneficial effect on students' resilience and prosocial behavior.⁵¹ The loss of teacher support means that students failing to receive educational intervention are likely to experience stronger negative effects of air pollution on their psychological resilience and subsequent behavior.

Third, this paper enriches the research on the social cost of air pollution for adolescents. Air pollution has long been considered to harm individual physical and mental health development.^{14,52} Our study further reveals its negative effect on adolescents' prosocial behavior, which has a significant positive impact on adolescent development, such as improved academic performance, enhanced health status, social acceptance among peers, and subsequent social as well as political engagement. In other words, the adverse effects caused by air pollution may further affect the development of youth and society and thus causing greater social costs. Therefore, our research provides explicit evidence of the social costs of air pollution and reveals the need as well as urgency to tackle environmental pollution and other ecological hazards in the physical environment.

Practical Implications

Our study also offers several practical implications for parents, schools, and psychologists. Firstly, parents should pay attention to the negative effects of air pollution on adolescent development and implement positive intervention mechanisms to address such negative effects, especially in psychological and behavioral areas. For example, parents can improve their parenting style and home environment to provide more emotional support to alleviate the stress caused by the physical environment. Secondly, schools and teachers also need to take more responsibility for giving young people more mental and intellectual support. For example, teachers should communicate with students regularly or conduct regular counseling sessions to alleviate students' psychological stress. In addition, schools can organize special workshops to educate students on the adverse effects of air pollution and guide them on how to mitigate these adverse effects. Thirdly, our research alerts psychologists to pay attention to air pollution because poor air quality is a potential risk factor for the positive psychological and behavioral development of adolescents. Psychologists can take specialist medical measures to mitigate the negative psychological effects of air pollution

on young people and strengthen their psychological resilience in order to improve their subsequent behavioral problems.

Limitations and Future Research Directions

To our knowledge, this is one of the first studies to explore the mechanisms underlying the relationship between air pollution and adolescents' prosocial behavior. Combining data from a 3-year survey of 1301 Chinese adolescents with archival data on air quality, we found that adolescents' psychological resilience mediates the negative effects of air pollution on adolescent prosocial behavior, and that family as well as school factors moderate this chain of relationships. Our findings provide a comprehensive perspective to understand the complex relationship between air pollution, adolescent psychology and behavior, and their interpersonal relations. However, there are still some aspects to be further improved in this study. First, this study is limited to a single city. Scholars could further conduct comparative surveys in cities in northern China to verify whether the results are consistent. Second, rather than measuring total adolescents' prosocial behaviors in the form of a scale, future studies could combine other analytical skills, such as diary studies, to measure actual prosocial behaviors to improve validity. Third, our study adopted a quantitative approach, that is, a survey method to test our arguments. However, qualitative research methods need to be combined by scholars to further explore and interpret the effects of air pollution on the psychology and behavior of adolescents. For example, the researchers can use interviews or case studies to further understand the phenomenon of the impact of air pollution on adolescents. Fourth, it is necessary to conduct similar studies in several countries to explore whether and how environmental pollution harms adolescent development and improve the generalizability of the current research. Finally, how to counteract the negative effects of air pollution on the psychology and behavior of young people is also a research question worthy of further exploration. Future studies could explore whether and how the negative effects of air pollution change with the intervention of professional educational methods.

Conclusion

As a critical stage of human life, adolescence has an essential impact on the subsequent development of individuals. Nevertheless, our study suggests that air pollution significantly inhibits psychological capital and subsequent positive behavior of individuals during their adolescence. Furthermore, our findings indicate that a high level of family support weakens this negative influence while a low level of teacher support for an adolescent may exacerbate this damage. By revealing these findings, this study calls for both parents and schools to implement proactive intervention mechanisms to address the adverse effects of air pollution on adolescent development, especially on the psychological and behavioral aspects.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

This study was conducted strictly in compliance with the guidelines of the Declaration of Helsinki. Also, this study was approved by the administrative committees of the surveyed schools and the Human Research Ethics Committee of Shenzhen University (NO. 20160516, approved on June 22, 2016).

Funding

This research was funded by the Natural Science Foundation of Guangdong Province (#2021A1515011330), the Fund for Philosophy and Social Science of Shenzhen Municipality, China (#SZ2018B007), the Shenzhen Education Science Planning Project (#cgpy21001), and the Shenzhen University-Lingnan University Joint Research Programme (#202202001).

Disclosure

The authors have no conflicts of interest to disclose in this work.

References

1. Caprara GV, Kanacri BPL, Gerbino M, et al. Positive effects of promoting prosocial behavior in early adolescence: evidence from a school-based intervention. *Int J Behav Dev.* 2014;38(4):386–396. doi:10.1177/0165025414531464
2. Li B, Hu X, Chen L, Wu C. Longitudinal relations between school climate and prosocial behavior: the mediating role of gratitude. *Psychol Res Behav Ma.* 2023;16:419–430. doi: 10.2147/PRBM.S395162.
3. Gerbino M, Zuffianò A, Eisenberg N, et al. Adolescents' prosocial behavior predicts good grades beyond intelligence and personality traits. *J Pers.* 2018;86(2):247–260. doi:10.1111/jopy.12309
4. Putra IGNE, Astell-Burt T, Cliff DP, Vella SA, John EE, Feng X. The relationship between green space and prosocial behaviour among children and adolescents: a systematic review. *Front Psychol.* 2020;11:1–20. doi:10.3389/fpsyg.2020.00859
5. Haroz EE, Murray LK, Bolton P, Betancourt T, Bass JK. Adolescent resilience in Northern Uganda: the role of social support and prosocial behavior in reducing mental health problems. *J Res Adolesc.* 2013;23(1):138–148. doi:10.1111/j.1532-7795.2012.00802.x
6. Pakaslahti L, Karjalainen A, Keltikangas-Järvinen L. Relationships between adolescent prosocial problem-solving strategies, prosocial behaviour, and social acceptance. *Int J Behav Dev.* 2002;26(2):137–144. doi:10.1080/01650250042000681
7. Wentzel KR, Filisetti L, Looney L. Adolescent prosocial behavior: the role of self-processes and contextual cues. *Child Dev.* 2007;78(3):895–910. doi:10.1111/j.1467-8624.2007.01039.x
8. Padilla-Walker LM, Nielson MG, Day RD. The role of parental warmth and hostility on adolescents' prosocial behavior toward multiple targets. *J Fam Psychol.* 2016;30(3):331–340. doi:10.1037/fam0000157
9. Lenzi M, Vieno A, Perkins DD, Pastore M, Santinello M, Mazzardis S. Perceived neighborhood social resources as determinants of prosocial behavior in early adolescence. *Am J Commun Psychol.* 2012;50(1):37–49. doi:10.1007/s10464-011-9470-x
10. Coyne SM, Padilla-Walker LM, Holmgren HG, et al. A meta-analysis of prosocial media on prosocial behavior, aggression, and empathic concern: a multidimensional approach. *Dev Psychol.* 2018;54(2):331–347. doi:10.1037/dev0000412
11. Chew SH, Huang W, Li X. Does haze cloud decision making? A natural laboratory experiment. *J Econ Behav Organ.* 2021;182:132–161. doi:10.1016/j.jebo.2020.12.007
12. Lin WH, Pan WC, Yi CC. Happiness in the air? The effects of air pollution on adolescent happiness. *BMC Public Health.* 2019;19(1):1–10. doi:10.1186/s12889-019-7119-0
13. Pun VC, Manjourides J, Suh H. Association of ambient air pollution with depressive and anxiety symptoms in older adults: results from the NSHAP study. *Environ Health Perspect.* 2017;125(3):342–348. doi:10.1289/EHP494
14. Becerra TA, Wilhelm M, Olsen J, Cockburn M, Ritz B. Ambient air pollution and autism in Los Angeles county. *California Environ Health Persp.* 2013;121(3):380–386. doi:10.1289/ehp.1205827
15. Yolton K, Khoury JC, Burkle J, LeMasters G, Cecil K, Ryan P. Lifetime exposure to traffic-related air pollution and symptoms of depression and anxiety at age 12 years. *Environ Res.* 2019;173:199–206. doi:10.1016/j.envres.2019.03.005
16. Aguglia A, Giacomini G, Montagna E, et al. Meteorological Variables and Suicidal Behavior: air Pollution and Apparent Temperature Are Associated With High-Lethality Suicide Attempts and Male Gender. *Front Psychiatry.* 2021;12:653390. doi:10.3389/fpsyg.2021.653390
17. Lu JG, Lee JJ, Gino F, Galinsky AD. Polluted morality: air pollution predicts criminal activity and unethical behavior. *Psychol Sci.* 2018;29(3):340–355. doi:10.1177/0956797617735807
18. Wu Z, Geng L. Traveling in haze: how air pollution inhibits tourists' pro-environmental behavioral intentions. *Sci Total Environ.* 2020;707:135569. doi:10.1016/j.scitotenv.2019.135569
19. Forns J, Dadvand P, Foraster M, et al. Traffic-related air pollution, noise at school, and behavioral problems in Barcelona Schoolchildren: a Cross-Sectional Study. *Environ Health Perspect.* 2016;124(4):529–535. doi:10.1289/ehp.1409449
20. Chen JF, Wu XJ, Tao R, Zhao N, Li S, Zhao R. Effects of air pollution on individuals' direct and spillover behaviors. *Adv Psychol Sci.* 2020;28:1293–1306. doi:10.3724/SP.J.1042.2020.01293
21. Masten A, Best K, Garmezy N. Resilience and development: contributions from the study of children who overcome adversity. *Dev Psychopathol.* 1990;2(4):425–444. doi:10.1017/S0954579400005812
22. Brownlee K, Rawana J, Franks J, et al. A systematic review of strengths and resilience outcome literature relevant to children and adolescents. *Child Adolesc Soc Wo.* 2013;30(5):435–459. doi:10.1007/s10560-013-0301-9
23. Zolkoski SM, Bullock LM. Resilience in children and youth: a review. *Child Youth Serv Rev.* 2012;34(12):2295–2303. doi:10.1016/j.childev.2012.08.009
24. Masten A. Ordinary magic: resilience processes in development. *Am Psychol.* 2001;56(3):227–238. doi:10.1037/0003-066X.56.3.227
25. Luthans F, Avey JB, Avolio BJ, Norman SM, Combs GM. Psychological capital development: toward a micro-intervention. *J Organ Behav.* 2006;27(3):387–393. doi:10.1002/job.373
26. Amerio A, Bertuccio P, Santi F, et al. Gender Differences in COVID-19 Lockdown Impact on Mental Health of Undergraduate Students. *Front Psychiatry.* 2022;12:813130. doi:10.3389/fpsyg.2021.813130
27. Mehta AJ, Kubzansky LD, Coull BA, et al. Associations between air pollution and perceived stress: the Veterans Administration Normative Aging Study. *Environ Health.* 2015;14:1–10. doi:10.1186/1476-069X-14-10
28. Bonanno GA, Galea S, Bucciarelli A, Vlahov D. What predicts psychological resilience after disaster? The role of demographics, resources, and life stress. *J Consult Clin Psych.* 2007;75(5):671–682. doi:10.1037/0022-006X.75.5.671
29. Flouri E, Midouhas E, Joshi H. The role of urban neighbourhood green space in children's emotional and behavioural resilience. *J Environ Psychol.* 2014;40:179–186. doi:10.1016/j.jenvp.2014.06.007
30. Taylor ZE, Eisenberg N, Spinrad TL, Eggum ND, Sulik MJ. The relations of ego-resiliency and emotion socialization to the development of empathy and prosocial behavior across early childhood. *Emotion.* 2013;13(5):822–831. doi:10.1037/a0032894
31. Alessandri G, Luengo Kanacri BP, Eisenberg N, et al. Prosociality during the transition from late adolescence to young adulthood: the role of effortful control and ego-resiliency. *Pers Soc Psychol Bull.* 2014;40(11):1451–1465. doi:10.1177/0146167214549321
32. Xie X, Chen W, Lei L, Xing C, Zhang Y. The relationship between personality types and prosocial behavior and aggression in Chinese adolescents. *Pers Individ Differ.* 2016;95:56–61. doi:10.1016/j.paid.2016.02.002

33. Zimmerman M, Stoddard S, Eisman A, Caldwell C, Aiyer S, Miller A. Adolescent resilience: promotive factors that inform prevention. *Child Dev Perspect.* 2013;7(4):215–220. doi:10.1111/cdep.12042
34. Davis-Kean PE. The influence of parent education and family income on child achievement: the indirect role of parental expectations and the home environment. *J Fam Psychol.* 2005;19(2):294–304. doi:10.1037/0893-3200.19.2.294
35. Eilertsen T, Thorsen AL, Holm SEH, Bøe T, Sørensen L, Lundervold AJ. Parental socioeconomic status and child intellectual functioning in a Norwegian sample. *Scand J Psychol.* 2016;57(5):399–405. doi:10.1111/sjop.12324
36. McLaughlin KA, Costello EJ, Leblanc W, Sampson NA, Kessler RC. Socioeconomic status and adolescent mental disorders. *Am J Public Health.* 2012;102(9):1742–1750. doi:10.2105/AJPH.2011.300477
37. Finkelstein DM, Kubzansky LD, Capitman J, Goodman E. Socioeconomic differences in adolescent stress: the role of psychological resources. *J Adolesc Health.* 2007;40(2):127–134. doi:10.1016/j.jadohealth.2006.10.006
38. Goodman E, McEwen BS, Dolan LM, Schafer-Kalkhoff T, Adler NE. Social disadvantage and adolescent stress. *J Adolesc Health.* 2005;37(6):484–492. doi:10.1016/j.jadohealth.2004.11.126
39. LaRusso MD, Romer D, Selman RL. Teachers as Builders of Respectful School Climates: implications for Adolescent Drug Use Norms and Depressive Symptoms in High School. *J Youth Adolesc.* 2008;37:386–398. doi:10.1007/s10964-007-9212-4
40. Östberg V, Plenty S, Låftman SB, Modin B, Lindfors P. School demands and coping resources— associations with multiple measures of stress in mid-adolescent girls and boys. *Int J Env Res Pub He.* 2018;15(10):2143. doi:10.3390/ijerph15102143
41. Shek DT, Ma CM. Dimensionality of the Chinese positive youth development scale: confirmatory factor analyses. *Soc Indic Res.* 2010;98:41–59. doi:10.1007/s11205-009-9515-9
42. Chen S, Guo C, Huang X. Air pollution, student health, and school absences: evidence from China. *J Environ Econ Manag.* 2018;92:465–497. doi:10.1016/j.jeem.2018.10.002
43. Heyes A, Zhu M. Air pollution as a cause of sleeplessness: social media evidence from a panel of Chinese cities. *J Environ Econ Manag.* 2019;98:102247. doi:10.1016/j.jeem.2019.07.002
44. Bai J. *Development of Chinese Adolescents' Risk Behaviors Scale.* Taiyuan, China: Shanxi University; 2007.
45. Davis AN, Carlo G, Schwartz SJ, et al. The longitudinal associations between discrimination depressive symptoms, and prosocial behaviours in US latino/a recent immigrant adolescents. *J Youth Adolesc.* 2016;45:457–470. doi:10.1007/s10964-015-0394-x
46. Paige Harden K, D'onofrio BM, Van Hulle C, et al. Population density and youth antisocial behavior. *J Child Psychol Psych.* 2009;50(8):999–1008. doi:10.1111/j.1469-7610.2009.02044.x
47. Baron R, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol.* 1986;51:1173–1182.
48. Costanza A, Amerio A, Aguglia A, et al. From The Interpersonal Theory of Suicide to The Interpersonal Trust: an unexpected and effective resource to mitigate economic crisis-related suicide risk in times of Covid-19? *Acta Biomed.* 2021;92(S6):e2021417. doi:10.23750/abm.v92iS6.12249
49. Acharya N, Joshi S. Influence of parents' education on achievement motivation of adolescents. *Indian J Social Sci Res.* 2009;6(1):72–79.
50. Manzano-Sánchez D, González-Villora S, Valero-Valenzuela A. Application of the Teaching Personal and Social Responsibility model in the secondary education curriculum: implications in psychological and contextual variables in students. *Int J Env Res Pub He.* 2021;18(6):3047. doi:10.3390/ijerph18063047
51. Berger R, Benatov J, Cuadros R, VanNattan J, Gelkopf M. Enhancing resiliency and promoting prosocial behavior among Tanzanian primary-school students: a school-based intervention. *Transcult Psychiatry.* 2018;55(6):821–845. doi:10.1177/1363461518793749
52. Buoli M, Grassi S, Caldiroli A, et al. Is there a link between air pollution and mental disorders? *Environ Int.* 2018;118:154–168. doi:10.1016/j.envint.2018.05.044

Psychology Research and Behavior Management

Dovepress

Publish your work in this journal

Psychology Research and Behavior Management is an international, peer-reviewed, open access journal focusing on the science of psychology and its application in behavior management to develop improved outcomes in the clinical, educational, sports and business arenas. Specific topics covered in the journal include: Neuroscience, memory and decision making; Behavior modification and management; Clinical applications; Business and sports performance management; Social and developmental studies; Animal studies. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/psychology-research-and-behavior-management-journal>