



Asthma and other allergic diseases in relation to suicidal behavior among South Korean adolescents

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ABSTRACT

Objectives: Adolescent asthma can be the cause of social and psychological problems. We investigated the association between asthma with other allergic diseases and suicidal risk behavior among South Korean adolescents using nationally representative data.

Methods: Web-based self-report data from the Korean Youth Risk Behavior Web-Based Survey were used in this study ($N = 237,022$). Complex sample logistic regression was used to define the relationship between suicidal behavior and asthma ($n = 7177$), with other allergic diseases [asthma with allergic rhinitis (AR) or asthma with atopic dermatitis (AD) ($n = 9720$), asthma with AD and AR ($n = 4971$)].

Results: Participants with asthma and other allergies showed a higher prevalence of substance use, greater sexual experience, greater perceived stress, poorer perceived health, more severe depression, more suicidal ideation, and more suicide attempts than those without allergy. Depression, suicidal ideation, and suicide attempts increased trend in the following order: no asthma, asthma only, asthma with one other allergy (asthma with AD or asthma with AR), and asthma with AD and AR. After adjusting for multiple confounders, the odds ratio for suicidal ideation with asthma and AD and AR was 1.13 [95% confidence interval (CI), 1.06–1.19] and that for suicide attempts was 1.31 (95% CI, 1.20–1.43).

Conclusions: Adolescent asthma and other allergies were associated with suicidal behavior.

1. Introduction

The Asia-Pacific region, including South Korea, has shown an increased prevalence of allergic diseases [allergic rhinitis (AR), asthma, and atopic dermatitis (AD)] in recent years [1]. Allergic diseases can cause physical symptoms (red eyes, watery rhinorrhea, pruritus, and breathing difficulty) and psychological problems (depression and anxiety) [2]. Suicide is the leading cause of death among adolescents in many countries [3] and suicide is the leading cause of death among Korean adolescents [4]. Suicidal behavior among adolescents has become a major public health problem in Korea; thus, it is important to determine the risk factors for suicidal behavior among adolescents. We showed previously that adult asthma is associated with suicidal behavior [5] and other studies have reported significant associations between asthma and suicidal ideation and suicide attempts [6] [7]. A recent systematic review article suggested a close link between asthma and suicidal behavior [8]. Patients with AR [9] and AD [10] are also at risk for suicidal behavior. Because AR, AD, and asthma share common IgE-mediated pathophysiological mechanisms, these allergic diseases

may have some shared effects on suicidal behavior.

AR and AD are frequently cooccurring diseases. Although the association between suicide and individual allergic diseases has been investigated, few studies have investigated the association between suicide and the simultaneous presence of several allergic diseases [11]. Asthma and allergic diseases have a negative impact on the quality of life and mood disorder. In addition, suicide is one of the most important causes of death in Korean schoolchildren. Therefore, it is very important to determine the association between allergic diseases and suicidal risk. So this study investigated whether there are associations between asthma with other allergic diseases and suicidal behavior among Korean adolescents.

2. Methods

2.1. Study participants

The study data were obtained from the 2007–2013 Korea Youth Risk Behavior Web-based Survey (KYRBWS), which was a nationwide

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based survey that investigated numerous health-related behaviors, including from a psychosocial perspective, of 12–18-year-old Korean adolescents. The population was stratified by 43 regional and school-type variables, and then the study sample was selected through school-type and class-type stages.

The KYRBWS survey was conducted by the Korea Centers for Disease Control and Prevention (KCDCP). The complex research design included multistage sampling, stratification, and clustering. The purpose of this survey was to determine the prevalence of health-risk behaviors in Korean adolescent students. All data collection procedures have been reported by the KCDCP. During the survey, participants were assigned identification (ID) numbers and guaranteed anonymity. Teachers randomly assigned a computer to each student and provided the survey information. After the process was sufficiently explained, each student accessed the website using his or her ID number and completed the survey [12]. The KYRBWS was approved by the Institutional Review Board of the KCDCP. Of the participating students, 7177 had asthma only, 9720 had asthma and AD or AR, and 4971 had asthma with AD and AR (no allergy, $n = 215,154$) in the final analysis.

2.2. Allergic diseases

Asthma was confirmed by answering “yes” to the following question: “Have you ever been diagnosed with asthma by a doctor?” AR was confirmed by answering “yes” to the following question: “Have you ever been diagnosed with allergic rhinitis by a doctor?” AD was confirmed by answering “yes” to the following question: “Have you ever been diagnosed with atopic dermatitis by a doctor?” We categorized the respondents into four groups: “no allergy,” “asthma only,” “asthma with one other allergy (asthma with AD or asthma with AR)” and “asthma with AD and AR.”

2.3. Socioeconomic and demographic factors

The self-administered KYRBWS questionnaire was used to obtain information on socioeconomic characteristics [age, sex, school type (middle, high, vocational high), area of residence, family structure, socioeconomic status (SES), years in school, and academic achievements], health behavior factors (smoking status, alcohol drinking status and exercise status). Residential area was divided into “district, small and medium city, large city”. Smoking status was determined by the following questions: “Have you ever smoked cigarettes, even once?”. If the answer was “yes,” another question was asked: “How many days did you smoke cigarettes during the last month?”. Those who responded “more than 1 day” were classified into the smoking group [13]. Alcohol drinking was determined by the following questions: “Have you ever consumed alcohol, even once?”. If the answer was “yes,” the following question was asked: “How many days did you drink alcohol in the last month?”. Those who responded “> 1 day” were classified into the alcohol group [13]. Academic performance was assessed by the following question: “During the past 12 months, how would you rate your academic performance?”. The answer options were “high,” “middle-high,” “middle,” “middle-low,” and “low.” Responses were categorized as high (high or middle-high), middle (middle), or low (middle-low or low). Regular exercise was determined by the following question: “how many days have you engaged in intense activity that caused an increase in breathing or heart rate for at least 60 min per day in the past 7 days?”. Responses were categorized as < 3 times/week or ≥ 3 times/week [14]. The parents' occupations and family income have been used most frequently to assess SES. However, some adolescents are unaware of the precise income of their household, while others are unwilling to divulge such information. Thus, SES assessment based on family income or parents' occupation was not feasible for our participants. The SES variable was instead assessed using the Family Affluence Scale (FAS). The FAS was introduced by the European Health Behavior in School-aged Children Study (HSBC) [15] and includes four questions: 1) “Do

you have your own bedroom?” (No = 0; Yes = 1), 2) “how often do you take family trips per year?” (Never = 0; Once = 1; Twice = 2; More than twice = 3), 3) “how many computers are in your home?” (None = 0, One = 1; Two = 2; More than two = 3); and 4) “how many vehicles does your family own?” (No = 0; Yes, one = 1; Yes, two = 2). The family affluence level (FAL) was calculated for each participant based on their responses to the four questions, and they were categorized into three groups according to the FAS score: low (score of 0–2), middle (score of 3–5), and high (score of 6–9). Because these four questions are easy for children and adolescents to answer, the FAS is can provide better information than conventional questions about family income.

2.3.1. Psychosocial measures

Psychosocial status was investigated in all participants. Sleep time was determined by the following question: “How many hours do you usually sleep per day?”. The responses were classified into five categories: ≤ 5, 6, 7, 8, or ≥ 9 h. We considered ≤ 5 h as “short sleep” and ≥ 9 h as “long sleep” [16]. Sleep satisfaction was assessed by the following question: “Did you feel refreshed after sleeping during the last week?”. The 5-point Likert scale responses were classified into five categories: very poor, poor, normal, good, and very good. The participants were asked the following question as an index of stress level: “Do you feel stress in your daily life?”. The responses were classified into five categories: none, some stress, moderate stress, high stress, and very high stress. Stress status was re-classified as low level (none or mild stress) or high level (moderate or severe stress) stress. Self-rated health status was determined by the following question: “In general, how do you feel about your health?”. Self-rated health status was classified into five categories: very good, good, fair, poor, or very poor. Health status was categorized as good (category includes very good), fair, or poor (category includes very poor). Sexual experience was determined by asking whether the participant had ever had sexual intercourse with either the same or different sex partner(s), or had never had sex. Illicit drug use was determined by the following question: “Have you ever inhaled/taken substances, such as glue, butane gas, stimulants, marijuana, amphetamine, heroin, high-dose cold medicine, or anxiolytics for mood elevation, hallucinations, or excessive dieting?”. Drug experience was categorized as “never experienced” or “ever experienced” [17].

Depression was assessed using the Korean version of the World Health Organization Composite International Diagnostic Interview-Short Form, which has been validated as a cost-effective screening method for health surveys [18]. The following question was used to assess depression: “During the previous year, did you have you ever had more than 2 weeks where you felt sad, blue, or depressed?”. Responses were categorized as “yes” or “no”. Suicidal ideation was determined the following question: “In the last 12 months, did you think about committing suicide?”. Responses were categorized as “yes” or “no”. This indicator is a well-validated predictor of suicide attempts that has been used in other surveys [19]. Suicide attempts were assessed by the following question: “In the last 12 months, did you try to commit suicide?”. Responses were categorized as “yes” or “no”.

2.4. Data analysis

All sampling and weighted variables were stratified, and the SPSS survey subroutines (SPSS Inc., Chicago, IL, USA) were used for all statistical analyses to ensure that the derived estimates and standard errors were appropriate. Survey sample weights were employed in all statistical procedures to yield non-biased estimates from descriptive and analytical analyses. Descriptive statistical methods were used to describe the basic characteristics of the study population; the numbers and percentages are reported for each variable. Student's *t*-test and the chi-square test were used to compare variables. Unadjusted logistic regression analysis was used to examine the associations between

asthma with allergic diseases and suicidal behavior, including suicidal ideation and attempts. The associations between suicidal behavior and asthma with allergic diseases were analyzed using the following methods: multiple logistic regression analysis with complex sampling adjusted for age and sex (model 1); and multiple logistic regression analysis with complex sampling adjusted for age, sex, school type, residence area, family structure, family affluence, smoking status, alcohol drinking status, regular exercise status, sleep duration, sleep satisfaction, substance use, sexual experience, perceived stress, health status and depressive mood (model 2). *P*-values < 0.05 were considered statistically significant. Sex-specific difference between suicidal behavior and asthma with allergic diseases were analyzed. Interaction may arise when considering the relationship among three or more variables, and describes a situation in which the effect of one causal variable on an outcome depends on the state of a second causal variable. To find interaction effects between sex and suicidal behaviors, we categorized the four groups into two groups (asthma with allergies vs. no asthma/asthma without allergies) and analysis interaction using multiple logistic regression analysis with an interaction term.

3. Results

The baseline characteristics of the study population (*N* = 237,022) are presented in Table 1. Adolescents with asthma [asthma only (*n* = 7177), asthma with AD or asthma with AR (*n* = 9720), asthma

with AD and AR (*n* = 4971)] were more frequently living in a large city, with a high SES (high FAS), and subjectively high academic achievement compared to those without allergy (*n* = 215,154).

Differences in mental health status between the adolescents with versus without asthma are presented in Table 2. The adolescents with asthma reported less sleep, lower sleep satisfaction, more substance use, more sexual experience, higher levels of moderate to severe stress, poorer perceived health status, and a more frequent depressed mood compared to the population without allergy. The proportion of adolescents with asthma who had suicidal ideation (asthma only, 36.7%; asthma with AD or asthma with AR, 37.2%; asthma with AD and AR, 37.7%) was higher than that in the population without allergy (33.2%; *p* < 0.001). The proportion of adolescents with asthma who attempted suicide (asthma only, 10.0%; asthma with AD or asthma with AR, 10.0%; asthma with AD and AR, 10.5%) was higher than that of the population without allergy (7.4%; *p* < 0.001).

The odds ratio (ORs) of suicidal ideation and attempts among the adolescents with asthma compared to those without allergy are presented in Table 3. A multivariate analysis adjusting for age and sex (model 1) revealed that the ORs for suicidal ideation and attempts were 1.21 [95% confidence interval (CI): 1.14–1.29] and 1.43 (95% CI: 1.32–1.55) for asthma only, 1.21 (95% CI: 1.16–1.27) and 1.43 (95% CI: 1.30–1.57) for asthma with AD or asthma with AR, 1.25 (95% CI: 1.19–1.32), and 1.44 (95% CI: 1.35–1.55) for asthma with AD and AR. After additional adjustments for other factors (age, sex, school type,

Table 1
Clinical, socioeconomic and demographic characteristics of study populations.

	Group 1	Group 2	Group 3	Group 4	P-value	Post hoc
	No allergy	Asthma only	Asthma with AD or Asthma with AR	Asthma with AD and AR		
	(<i>n</i> = 215,154)	(<i>n</i> = 7177)	(<i>n</i> = 9720)	(<i>n</i> = 4971)		
Sex					< 0.001	a,b,d,e,f
Boy	102846 (47.8)	4115 (57.3)	5315 (54.7)	2332 (46.9)		
Girl	112308 (53.2)	3062 (42.7)	4405 (45.3)	2639 (53.1)		
Age					< 0.001	a,b,c,d,f
12–14 years (Middle school)	105406 (49.0)	3956 (55.1)	4919 (50.6)	2676 (53.8)		
15–17 years (High school)	109748 (51.0)	3221 (44.9)	4801 (49.4)	2295 (46.2)		
School					< 0.001	a,b,c,d,e,f
Middle school	105406 (49.0)	3956 (55.1)	4919 (50.6)	2676 (53.8)		
Academic high school	84371 (39.2)	2339 (32.6)	3762 (38.7)	1820 (36.6)		
Vocational high school	25,377 (11.8)	882 (12.3)	1039 (10.7)	475 (9.6)		
Residence					< 0.001	a,b,c,d,e,f
District	26526 (12.3)	960 (13.3)	1075 (11.0)	480 (9.7)		
Small and medium city	88724 (46.2)	2940 (41.0)	4110 (42.3)	2088 (42.0)		
Large city	99904 (46.5)	3277 (45.7)	4535 (46.7)	2403 (48.3)		
Family					0.042	b
With parents	204784 (95.2)	6820 (95.0)	9200 (94.7)	4707 (94.7)		
Without Parents	10370 (4.8)	357 (5.0)	520 (5.3)	264 (5.3)		
Family affluence scale					< 0.001	a,b,c,d,e,f
Low	63535 (29.5)	2260 (31.5)	2567 (26.4)	1212 (24.4)		
Medium	96201 (44.7)	3063 (42.7)	4345 (44.7)	2173 (43.7)		
High	55418 (25.8)	1854 (25.8)	2808 (28.9)	1596 (31.9)		
Subjective academic achievement					< 0.001	a,b,c,d,e,f
Low	27646 (12.8)	1028 (14.3)	1177 (12.1)	594 (11.9)		
Middle-Low	55283 (25.7)	1944 (27.1)	2318 (23.8)	1139 (22.9)		
Middle	58225 (27.1)	1879 (26.2)	2515 (25.9)	1184 (23.8)		
High-middle	51115 (23.8)	1562 (21.8)	2563 (26.4)	1332 (26.8)		
High	22885 (10.6)	764 (10.6)	1147 (11.8)	722 (14.5)		
Smoking	25247 (11.7)	1074 (15.0)	1284 (13.2)	627 (12.6)	< 0.001	a,b,d,e
Alcohol	45169 (21.0)	1629 (22.7)	2246 (23.1)	1108 (22.3)	< 0.001	a,b,c
Regular exercise	54399 (28.1)	2017 (31.7)	2779 (31.4)	1443 (31.8)	< 0.001	a,b,c

AD: atopic dermatitis, AR: allergic rhinitis.

^a Group 1 vs. Group 2.

^b Group1 vs. Group 3.

^c Group1 vs Group 4.

^d Group 2 vs. Group 3.

^e Group 2 vs. Group 4.

^f Group 3 vs. Group 4.

Table 2
Psychosocial characteristics of asthma patients.

	Group 1	Group 2	Group 3	Group 4	P-value	Post hoc
	No allergy	Asthma only	Asthma with AD or AR	Asthma with AD and AR		
	(n = 215154)	(n = 7177)	(n = 9720)	(n = 4971)		
Sleep duration, h					< 0.001	a,b,c,d,e,f
≤5	66102 (30.7)	1961 (27.3)	3195 (32.9)	1715 (34.5)		
6	51613 (24.0)	1627 (22.7)	2327 (23.9)	1202 (24.2)		
7	51050 (23.7)	1772 (24.7)	2169 (22.3)	1120 (22.5)		
8	35170 (16.3)	1306 (18.2)	1533 (15.8)	703 (14.2)		
≥9	11219 (5.3)	511 (7.1)	496 (5.1)	231 (4.6)		
Sleep satisfaction					< 0.001	a,b,c,d,e
Not enough at all	29341 (13.6)	1051 (14.6)	1597 (16.4)	843 (17.0)		
Not enough	60913 (28.3)	1955 (27.2)	2835 (29.2)	1425 (28.7)		
A little	69743 (32.4)	2297 (32.0)	3017 (31.0)	1579 (31.8)		
Enough	40496 (18.9)	1338 (18.7)	1651 (17.0)	799 (16.1)		
Plenty	14661 (6.8)	536 (7.5)	620 (6.4)	325 (6.4)		
Substance use	2485 (1.2)	149 (2.1)	190 (2.0)	123 (2.5)	< 0.001	a,b,c,e,f
Sexual experience	10464 (4.9)	451 (6.3)	587 (6.0)	286 (5.8)	< 0.001	a,b,c
Perceived Stress					< 0.001	a,b,c,d,e,f
Moderate to severe	33257 (15.5)	1274 (17.8)	1843 (19.0)	1019 (20.5)		
None to mild	181897 (84.5)	5903 (82.2)	7877 (81.0)	3952 (79.5)		
Perceived health status					< 0.001	a,b,c,d,e
Good	112323 (52.2)	3615 (50.4)	4763 (49.0)	2426 (48.8)		
Fair	67717 (31.5)	2252 (31.4)	3033 (31.2)	1490 (30.0)		
Poor	35114 (16.3)	1310 (18.2)	1924 (19.8)	1055 (21.2)		
Experiences of depressive mood for 2 or more continuous weeks	85993 (40.0)	3129 (43.6)	4357 (44.8)	2330 (47.0)	< 0.001	a,b,c,e,f
Suicidal ideations	71411 (33.2)	2633 (36.7)	3616 (37.2)	1876 (37.7)	< 0.001	a,b,c
Suicidal attempts	15922 (7.4)	718 (10.0)	972 (10.0)	520 (10.5)	< 0.001	a,b,c

AD: atopic dermatitis, AR: allergic rhinitis.

^a Group 1 vs. Group 2.

^b Group1 vs. Group 3.

^c Group1 vs Group 4.

^d Group 2 vs. Group 3.

^e Group 2 vs. Group 4.

^f Group 3 vs. Group 4.

Table 3
Adjusted relative odds (95% CI) on Multivariate Analysis of the Association Between asthma and suicidal ideations and suicidal attempts.

	Unadjusted	Model 1	Model 2
	ORs (95% CI)	Adjusted ORs (95% CI)	Adjusted ORs (95% CI)
Suicidal ideations			
No allergy	Reference	Reference	Reference
Asthma only	1.17 (1.12–1.22)	1.21 (1.14–1.29)	1.08 (1.01–1.17)
Asthma with AD or asthma with AR	1.20 (1.14–1.25)	1.21 (1.16–1.27)	1.10 (1.03–1.17)
Asthma with AD and AR	1.22 (1.15–1.29)	1.25 (1.19–1.32)	1.13 (1.06–1.19)
P-trend			0.027
Suicidal attempts			
No allergy	Reference	Reference	Reference
Asthma only	1.17 (1.12–1.22)	1.43 (1.32–1.55)	1.23 (1.10–1.38)
Asthma with AD or asthma with AR	1.19 (1.14–1.25)	1.43 (1.30–1.57)	1.27 (1.15–1.41)
Asthma with AD and AR	1.22 (1.15–1.29)	1.44 (1.35–1.55)	1.31 (1.20–1.43)
P-trend			< 0.001

AD: atopic dermatitis, AR: allergic rhinitis, ORs: odd ratios.

Adjusted for age and sex (model 1) and adjusted for age, sex, school type, residence area, family structure, family affluence scale, smoking, alcohol, regular exercise, sleep duration and satisfaction, substance use, sexual experience, perceived stress and health status, depressive mood (model 2).

residence area, family structure, family affluence scale, smoking, alcohol, regular exercise, sleep duration and satisfaction, substance use, sexual experience, perceived stress and health status, and depressive mood; model 2), the ORs for suicidal ideations (P-trend 0.027) and attempts (P-trend < 0.001) were 1.08 (95% CI: 1.01–1.17) and 1.23 (95% CI: 1.10–1.38) for asthma only, 1.10 (95% CI: 1.03–1.17) and 1.27 (95% CI: 1.15–1.41) for asthma with AD or with AR, 1.13 (95% CI: 1.06–1.19), and 1.31 (95% CI: 1.20–1.43) in asthma with AD and AR,

respectively. Table 4 showed sex-specific ORs for suicidal ideations and attempts. In boys, ORs for suicidal ideations and attempts were 1.09 (95% CI: 1.00–1.18) and 1.24 (95% CI: 1.06–1.45) for asthma only, 1.21 (95% CI: 1.17–1.34) and 1.47 (95% CI: 1.30–1.67) for asthma with AD or with AR, 1.29 (95% CI: 1.09–1.33), and 1.31 (95% CI: 1.07–1.59) in asthma with AD and AR, respectively. In girls, ORs for suicidal ideations and attempts were 1.25 (95% CI: 1.15–1.31) and 1.41 (95% CI: 1.23–1.61) for asthma only, 1.28 (95% CI: 1.19–1.37) and 1.42

Table 4

Sex specific adjusted relative odds (95% CI) on Multivariate Analysis of the Association Between asthma and suicidal ideations and suicidal attempts.

Boys	Adjusted ORs (95% CI)
No allergy	Reference
Suicidal ideations	
Asthma only	1.09 (1.00–1.18)
Asthma with AD or asthma with AR	1.21 (1.17–1.34)
Asthma with AD and AR	1.29 (1.09–1.33)
Suicidal attempts	
Asthma only	1.24 (1.06–1.45)
Asthma with AD or asthma with AR	1.31 (1.07–1.59)
Asthma with AD and AR	1.47 (1.30–1.67)
Girls	Adjusted ORs (95% CI)
No allergy	Reference
Suicidal ideations	
Asthma only	1.25 (1.15–1.31)
Asthma with AD or asthma with AR	1.28 (1.19–1.37)
Asthma with AD and AR	1.30 (1.19–1.41)
Suicidal attempts	
Asthma only	1.41 (1.23–1.61)
Asthma with AD or asthma with AR	1.42 (1.28–1.59)
Asthma with AD and AR	1.44 (1.27–1.64)

AD: atopic dermatitis, AR: allergic rhinitis, ORs: odd ratios.

Adjusted for age, school type, residence area, family structure, family affluence scale, smoking, alcohol, regular exercise, sleep duration and satisfaction, substance use, sexual experience, perceived stress and health status, depressive mood.

(95% CI: 1.28–1.59) for asthma with AD or with AR, 1.30 (95% CI: 1.19–1.41), and 1.44 (95% CI: 1.27–1.64) in asthma with AD and AR, respectively. Association between asthma with allergies and suicidal behavior is significantly higher in girls than boys (suicidal ideations: p -value < 0.001, suicidal attempts: p -value < 0.001).

4. Discussion

In this study, based on a nationwide sample of Korean adolescents, asthma and allergic diseases were associated with suicidal behavior even after adjusting for multiple confounding factors, including depression. These findings support a connection between allergic diseases, such as asthma, and suicidality.

Allergies are not only limited to physical effects, e.g., red eyes, runny nose, sneezing, itchiness, breathing difficulties, hives, they are often coupled with other consequences, including reduced cognitive ability, disturbances in sleep patterns, and impoverished quality of life [20]. In addition to these adverse physical and social impacts, a number of studies consistently linked atopy to poor psychological outcomes, including major depression and anxiety [2]. A recent systematic review presented a link between asthma and suicidal behaviors [8].

A few studies have investigated the relationship between allergic diseases and suicidal behavior among adolescents [21] [22] [23] [24]. A study from Norway reported that adolescents who currently had AD had a significantly higher risk of suicidal ideation than those without [21]. A study from Korea reported that adolescent AR is associated with suicidal ideation [22] and another Korean study showed that excessive internet use could be a mediating factor between allergic diseases, such as AR, and suicidal behavior [23]. A study from Taiwan with a 12-year follow-up duration showed that the incidence rate of mortality by suicide in adolescents with asthma was more than twice that of those without asthma [24].

The rates of anxiety, depression and sleep disturbance (suicide risk factors) are greater in patients with allergic diseases than in the general population. The rate of allergy is also greater in patients with

depression. Clinicians should actively inquire to diagnose allergy in patients with depression and depression in patients with allergy.

The precise pathogenic mechanism between allergic diseases and suicidal behavior has not been clearly elucidated. Clinicians have long observed that allergic diseases co-exist with psychological problems, such as fatigue, poor memory, irritability, and depression, which has been called “allergic toxemia” [25]. The increase in suicidal risk behaviors in patients with an allergic disease peaks during the spring time when aeroallergen levels are at their highest [26]. We hypothesized that increased pollen in the air during the spring may make pollen-sensitized allergic adolescents feel ill and trigger immune-related inflammatory cytokine expression. This neurobiological pathogenesis explains why patients with allergic disease more often have psychological diseases, such as depression or anxiety [27]. These neurobiological results suggest a close association between allergic diseases and suicidal behavior. Zhu M et al., showed that helper T cell imbalance in asthma can induce psychological symptoms [28]. This finding provided an improved understanding of the immune-inflammation responses in patients with asthma, and offered information for new targeted therapy to patients with asthma and with psychological symptoms. Another pathogenic mechanism linking allergic diseases and suicidal behavior is drugs for allergies. Glucocorticoids, such as hydrocortisone, are often prescribed for patients with asthma and other allergic diseases and may be another risk factor for suicidal behavior. Fardet et al. showed that glucocorticoid-prescribed groups were twice as likely to experience depression, and had a seven-fold increased risk of mortality from suicide, than a group not prescribed a glucocorticoid [29]. To the contrary, Voaklander et al., showed no difference in suicide risk was associated with glucocorticoids use [30].

Our study also showed greater sleep disturbance and sleep dissatisfaction among adolescents with asthma and allergic diseases than those without asthma. Sleep impairment is very common among patients with asthma, where waking from sleep may occur due to an asthma attack, pruritus or watery rhinorrhea. This sleep impairment appears to be a consistent predictor of suicidal behavior [31]. Thus,

sleep impairment, which is a common feature of patients with allergic diseases, may serve as another important pathophysiological link between allergic diseases, mood, and suicidal behavior [32].

Suicidal behavior is associated with health behavioral factors, such as cigarette smoking [33], alcohol consumption [34], and regular exercise [35] [36]. Thus, this study investigated these health behavioral factors, among others. SES is another important risk factor for suicidal behavior [37]. The FAS measurement was validated in the HSBC survey [38] and was associated with fewer missing responses than conventional questions on SES, and was thus determined to be suitable for a cross-sectional nationwide survey such as ours. Although social, economic, and cultural differences between Korea and other European countries exist, the FAS is a reliable measure of SES among Korean adolescents and shows compatible results with other SES indicators [15]. Previous studies on suicidal behavior in adolescents with asthma and allergic diseases did not assess SES using the FAS [39] [23] [40]. This is the first study to assess suicidal behavior in this population using the FAS. Although other studies using Korean Youth Risk Behavior Web-Based Survey data showed similar prevalence of suicidal behaviors [39,41], our study showed prevalences of suicide attempts (7–10%) and suicidal ideation (33–38%) in the past 12 months seems relatively higher than other country.

The present study had several limitations. First, its cross-sectional nature limited our certainty about the relationships of asthma with allergic diseases and suicidal behavior. Second, this survey was conducted in a school computer room and the data were collected by self-report questionnaires only. Because certain sensitive questions, such as those relating to suicidal behavior and psychosocial factors, may have influenced student's replies based on their peer group, bias cannot be ruled out. Third, we did not assess treatment types, including corticosteroid use, nor did we the severity of asthma and other allergic diseases because of a lack of any such information. Finally, in this study, the prevalence of suicidal ideation was > 30%, which means that ORs for suicidal ideation in asthma with allergic diseases will substantially overestimate relative risk (i.e., the true relative risks are actually lower).

Nevertheless, this survey used a large and representative sample of Korean adolescents, and all analyses were based on sample weights and adjusted for multiple confounding risk factors for suicidal behavior, including depression. Finally, previous studies on suicidal behaviors in Korean adolescents with asthma and allergic diseases did not assess SES using the FAS [39] [23] [40]; this is the first study to assess suicidal behavior in adolescents with asthma and allergic diseases using the FAS assessment.

In conclusion, asthma and allergic diseases were associated with the risk of suicidal behavior. Future prospective studies are required in the mental health and asthma and allergic disease fields, as well as studies aimed at developing preventive strategies to decrease suicidal behavior. These findings support further investigation into the asthma and allergic diseases and their links to suicidal ideation and behavior. Our results may also provide an empirical foundation for including asthma and allergic diseases in the clinical assessment of suicide risk, which ultimately may help identify individuals at high risk for suicide. Clinicians should actively inquire to assess suicidal risk in asthma with allergic diseases. Collaboration between allergists and mental health professionals is expected to lead to synergistic mental health care of patients with asthma and allergic diseases.

Author contributions

All authors contributed conception, analysis, interpretation, revising, and final approval of the manuscript. CH Han take responsibility for the integrity of the data and the accuracy of the data analysis. JH Chung served as a principal investigator and had full access to all of the data in the study.

Conflict of interest

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