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Sex differences in auditory verbal hallucinations in early, middle, and late adolescence: Results from a survey of 17,451 Japanese students aged 12–18 years

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Sex differences in auditory verbal hallucinations in early, middle, and late adolescence: Results from a survey of 17,451 Japanese students aged 12–18 years

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Abstract:

Objectives: Women have higher rates of auditory verbal hallucinations (AVH) than men do; however, less is known about sex differences in the prevalence of AVH among early, middle, and late adolescence; therefore, we sought to elucidate these differences in the prevalence of AVH and examine what degree any differences could be explained by differences in levels of depressive symptoms.

Design: We used a cross-sectional design and a self-reported questionnaire.

Setting: Participants were recruited from public junior and senior high schools in Tsu, Mie Prefecture and Kochi Prefecture, Japan.

Participants: Recruited participants comprised 19,436 students and 18,250 agreed to participate. Of these, the responses from 17,451 students were analysed (aged 12–18 years, M_{age} = 15.2 years (SD = 1.7), 50.6% women).

Measures: AVH was assessed by one of four items adopted from the schizophrenia section of the Japanese version of the Diagnostic Interview Schedule for Children. Depressive symptoms were assessed using a 12-item General Health Questionnaire.

Results: The prevalence of AVH was 7.0% among early adolescents (aged 12–13 years), 6.2% among middle adolescents (aged 14–15 years), and 4.8% among late adolescents (aged 16–18 years). Being a woman was significantly associated with a higher prevalence of AVH through adolescence (OR = 1.71, 95% CI: 1.31–2.23 in early adolescence; OR = 1.42, 95% CI 1.14–1.76 in middle adolescence; and OR = 1.52, 95% CI 1.23–1.87 in late adolescence); however, these differences became non-significant after adjusting for depressive symptoms (OR = 1.21, 95% CI: .92–1.60; OR = 1.00, 95% CI: .80-1.25; OR = 1.16, 95% CI: .93-1.44, respectively).

Conclusion: Sex differences in auditory hallucinations are seen in both adult and youth populations. The higher rates of auditory verbal hallucinations seen in girls may be secondary to the differences in the rate of depressive symptoms.

Key words: hallucination, sex differences, adolescents, general population

Article Summary:

Article focus:

・The study was to investigate sex differences in the prevalence of AVH through early, middle, and late adolescence.

Key message:

・Higher rates of AVH in girls was confirmed among early, middle, and late adolescents.

・Depressive symptoms may affect to higher rates of AVH among adolescent girls.

Strengths and limitations of this study:

・The data were collected from a large general adolescent population.

・Cross-sectional study

Introduction:

Auditory verbal hallucinations (AVH) are experienced not only by patients with psychotic disorders, but also by patients with nonpsychotic psychiatric disorders and by a substantial part of the general population[1]. Recent meta-analyses reported that around 4–5% of the general adult population have experienced AVH[1] and a median prevalence of psychotic symptoms (predominantly hearing voices) to be 17% in a general childhood sample (aged 9–12 years) and 7.5% of adolescent samples (aged 13–18 years)[2].

Previous studies have investigated sex differences in the prevalence of AVH among adolescents; however, the results are controversial. In adult populations, women have a higher incidence of positive psychotic symptoms[3], specifically auditory hallucinations[4 5], than men do. This sex difference may be mediated by depressive symptoms[3 5]. Similarly, girls report slightly more hallucinations than boys do[6]. By contrast, Kelleher et al. reported a trend for (non-specified) psychotic symptoms being more prevalent among mid-adolescent boys than girls[7]; however, this study was limited by its small sample size. Recently, a large population-based survey of 9,646 Norwegian adolescents reported that being a woman was significantly associated with a higher prevalence of AVH, and that the difference was mediated by affective symptoms[8]. However, the age range of this sample was 16–19 years. No study has investigated sex differences in the prevalence of AVH from early to late adolescence in a large population based survey.

Therefore, we investigated sex differences in the prevalence of in AVH in early, middle, and late adolescence using data from a large population based survey of 17,451 Japanese adolescents aged 12–18 years. We also explored to what degree any such differences could be explained by differences in levels of depressive symptoms in each age group.

Methods:

2.1 Study design and procedure

We employed an anonymous, cross-sectional survey in Japan with adolescent students from public junior high schools (grades 7–9, age range = 12–15 years) and public senior high schools (grades 10–12, age range = 15–18 years). The survey was conducted between 2008 and 2009 using a self-reported questionnaire. The principal investigators of the study asked all heads and administrators of public junior high schools in Tsu, Mie Prefecture and public junior high and senior high schools in Kochi Prefecture to participate. Of the 138 junior and 36 senior high schools invited, 47 (34%) junior and 30 (83%) senior high schools participated.

Parents were informed of the research project by letter and asked to notify the school if they did not want their child to participate. On the day of the survey, students were also given the choice of opting out. Each teacher reported the number of students present and absent on the day of the survey. This study was approved by the ethics committees of the Tokyo Metropolitan Institute of Medical Science, Mie University School of Medicine, and Kochi Medical School.

2.2 Participants

Of the recruited 19,436 students, 18,250 agreed to participate. Among these, 798 were absent on the day of the survey and 388 declined to participate. Among those agreeing, 799 were excluded from the analysis because of incomplete answers to question regarding psychotic-like experiences. Therefore, responses from 17,451 students (aged 12–18 years, M_{age} = 15.2 years (standard deviation (SD) = 1.7), 50.6% women) were analysed (valid response rate = 89.8%). Table 1 shows the adolescent groups by age and sex.

2.3 Measures

The participants were asked to complete an anonymous, self-reported questionnaire including questions about age, sex, and the following variables:

AVH

AVH was assessed by one of four items adopted from the schizophrenia section of the Diagnostic Interview Schedule for Children (DISC-C).[9] A Japanese version of the DISC-C was developed using a translation and back-translation method and has already been used in several previous studies conducted in Japan[10-14]. AVH was assessed with the following item, 'Have you ever heard voices that other people cannot hear?' Answers were provided on a three-point scale: '*no*', '*maybe*', and '*yes*, *definitely*'. In addition, we asked if AVH was experienced within the last six months. We defined adolescents who answered '*yes, definitely*' and who had AVH within the last six months as those who had experienced AVH.

Depressive symptoms

Depressive symptoms were assessed using a 12-item General Health Questionnaire (GHQ-12). The GHQ-12 is one of the most widely used self-report measures for assessing depression.[15] It has been used and validated in younger samples as well as in adults.[16] In addition, previous studies have established the validity and reliability of the Japanese version of this instrument.[17] A four-point scale recorded into binary scoring (0-0-1-1) was used for the 12 GHQ items. Responses for each question were added together to form a total score with a range between 0 (best possible) and 12 (worst possible).

2.4 Statistical Analysis

We examined the effect of sex differences on the prevalence of AVH using a multivariate logistic regression. We initially tested the interaction effect between sex and age on the prevalence of AVH to see if the effect of sex was modified by age. Then we calculated the odds ratio (OR) of the effect of sex differences on the prevalence of AVH. In addition to the crude OR, we calculated the adjusted OR after adjusting for depressive symptoms. The significance level was set to $p < .05$. All statistical analyses were conducted using the IBM Statistical Package for Social Sciences (SPSS), version 21.0 for Windows (IBM Corp, New York, USA).

Results:

3.1 Prevalence of AVH and depressive symptoms

The prevalence of AVH within six months was 5.7% in adolescence: 7.0% in early adolescence (aged 12–13 years), 6.2% in middle adolescence (aged 14–15 years), and 4.8% in late adolescence (aged 16–18 years). GHQ-12 scores were 2.9 (SD = 3.0), 3.4 (SD = 3.1), and 3.9 (SD = 3.2) in early, middle, and late adolescence, respectively.

3.2 Sex differences in the prevalence of AVH in early, middle, and late adolescence

The prevalence of AVH within six months was higher among women than men (chi-square = 38.1, df = 1, $p < .001$). The prevalence of AVH within six months by sex and the three age groups is shown in Figure 1. Since the interaction effect between sex and age on AVH prevalence was significant ($p < .001$), we conducted logistic regression analyses in each of the three age groups. Being a woman was significantly associated with a higher prevalence of AVH in all three age groups (early adolescence: OR = 1.71, 95% confidence interval (CI): 1.31–2.23; middle adolescence: OR = 1.42, 95% CI: 1.14–1.76; and late adolescence: OR = 1.52, 95% CI: 1.23–1.87) (Table 2).

3.3 Sex differences in the prevalence of AVH and depressive symptoms

After adjusting for depressive symptoms, the influence of sex differences on the prevalence of AVH did not remain significant for any of the three age groups (early adolescence: OR = 1.21, 95% CI: .92–1.60; middle adolescence: OR = 1.00, 95% CI: .80–1.25; and late adolescence: OR = 1.16, 95% CI: .93–1.44) (Table 2).

Discussion:

This was the first study to investigate sex differences in the prevalence of AVH through early, middle, and late adolescence in a large population-based survey. The results revealed that sex differences in AVH that have been seen in general adult populations were also observed among adolescents. The effect of sex was greater in early than it was in middle or late adolescence. However, for all age groups, a higher prevalence of AVH in girls may be secondary to differences in depressive symptoms.

The prevalence of AVH within the last six months (5.7%) was comparable to previous results.[7 8] The prevalence of AVH was higher in early adolescence than it was in late adolescence. This was in line with previous findings that showed that the prevalence of psychotic experiences decreases along with age during adolescence.[7]

The prevalence of AVH was higher among female adolescents than it was for males in all three stages of adolescence. However, being female was more strongly associated with an increased prevalence of AVH in early adolescence than it was in middle to late adolescence. Moreover, the effect of being female on the prevalence of AVH did not remain after controlling for GHQ score.

Bidirectional associations between AVH and depressive symptoms may be hypothesized. Adolescents with AVH may be more distressed because of their AVH; on the other hand, depressive symptoms may make adolescents more vulnerable to psychotic experiences. Unfortunately, our cross-sectional data would not allow any further differentiation in causal relationships.

Several limitations of our study should be noted. First, information was not available about further confounding factors that may be associated with AVH such as socioeconomic status, family circumstances, and abuse history. Second, although we had good compliance among high school students (83%) in Kochi Prefecture, we could not achieve the same levels of participation in junior high schools in Tsu City and Kochi Prefecture, where only 47 (34%) of the 138 junior high schools agreed to participate. This was because of refusal by the Educational Committee in Kochi Central City, which supervises most junior high schools in our targeted regions. Lastly, as noted above, we used a cross-sectional sample; therefore, we were not able to identify causal relationships among sex differences, depressive symptoms, and AVH. Follow-up studies are needed to address these issues.

Despite these limitations, this study has significant strengths. First, this was one of the largest studies to date to examine the prevalence of psychotic experiences of adolescents. Second, we examined this phenomenon through three distinct stages of adolescence; therefore, we examined the effect of sex and depressive symptoms across different age ranges.

This study has some practical implications. Teachers and specialists in adolescent mental health are advised to be warier of both hallucinatory experiences and depressive symptoms among adolescents. AVH are more prevalent than earlier believed and are

more frequent among girls than they are among boys. Understanding this may allow teachers and specialists to more effectively identify and help those in distress.

Authors' contributions:

YMorokuma, KE, AN, SY, SA, YMorimoto, MN, YO, TAF, SM, and SS conceptualized the study. YMorokuma, KE, AN, SY, TAF, and SS wrote the first draft of the manuscript. YMorokuma, KE, AN, and SY conducted the statistical analyses. SY, SS, and AN helped in the design of the study and the management of the database. SS and AN managed the survey process in the field. All authors contributed to and have approved the final manuscript.

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Competeng interests:

None.

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Data sharing statement:

This study was planned and conducted in accordance with the ethics committee of the Tokyo Metropolitan Institute of Medical Science. When applying to the research ethics committee for our data set, we did not request this to be released as public data. However, the data can made available to all interested researchers upon request to Syudo Yamasaki Ph.D.

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Table 1. Age and sex breakdown of the 17,451 adolescents

Age (years)	Male, n (%)	Female, n (%)	Total, n
12–13	1,826 (52.0)	1,687 (48.0)	3,513
14–15	2,956 (50.3)	2,920 (49.7)	5,876
16–18	3,838 (47.6)	4,224 (52.4)	8,062
Total	8,620 (49.4)	8,831 (50.6)	17,451

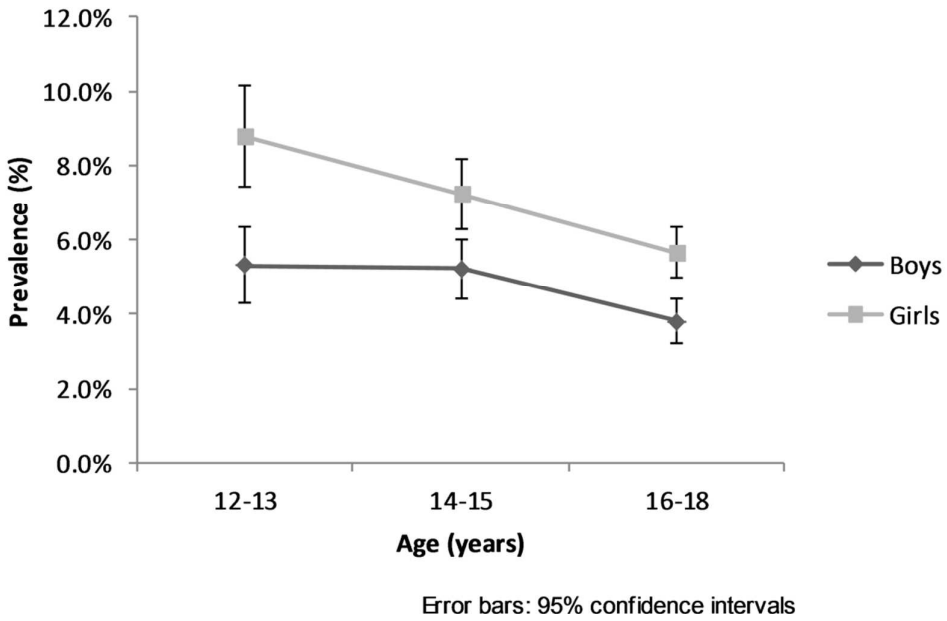

Figure 1. Prevalence of auditory hallucinations by sex and age groups

Table 2. Logistic regression for sex differences in predicting auditory hallucination.

	Unadjusted model			Adjusted model		
Age (years)	OR	95% CI	p	OR	95% CI	p
12–13	**1.71**	**(1.31–2.23)**	**< .001**	1.21	(.92–1.60)	.178
14–15	**1.42**	**(1.14–1.76)**	**.001**	1.00	(.80–1.25)	.983
16–18	**1.52**	**(1.23–1.87)**	**< .001**	1.16	(.93–1.44)	.188

OR: odds ratio; CI: confidence interval.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) 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	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	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	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	5,6
Bias	9	Describe any efforts to address potential sources of bias	5
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	5,6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) 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	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7,12
		(b) Indicate number of participants with missing data for each variable of interest	-
Outcome data	15*	Report numbers of outcome events or summary measures	7,12
Main results	16	(*a*) 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	7, 13,14
		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
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	8

Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
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	9

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Abstract:

Objectives: Women have higher rates of auditory verbal hallucinations (AVH) than men; however, less is known about sex differences in the prevalence of AVH in early, middle, and late adolescence. We sought to elucidate the differences in the prevalence of AVH and to examine the degree to which these differences could be explained by differences in levels of depressive symptoms.
Design: We used a cross-sectional design and a self-reported questionnaire.
Setting: Participants were recruited from public junior and senior high schools in Tsu, Mie Prefecture and Kochi Prefecture, Japan.
Participants: In total, 19,436 students were contacted and 18,250 participated. Responses from 17,451 students with no missing data were analysed (aged 12–18 years, M_{age} = 15.2 years (SD = 1.7), 50.6% girls).
Measures: AVH were assessed through one of four items adopted from the schizophrenia section of the Japanese version of the Diagnostic Interview Schedule for Children. Depressive symptoms were assessed using the 12-item General Health Questionnaire.
Results: The prevalence of AVH was 7.0% among early adolescents (aged 12–13 years), 6.2% among middle adolescents (aged 14–15 years), and 4.8% among late adolescents (aged 16–18 years). Being female was significantly associated with a higher prevalence of AVH through adolescence (OR = 1.71, 95% CI: 1.31–2.23 in early adolescence; OR = 1.42, 95% CI 1.14–1.76 in middle adolescence; and OR = 1.52, 95% CI 1.23–1.87 in late adolescence); however, these differences became non-significant after adjusting for depressive symptoms (OR = 1.21, 95% CI: .92–1.60; OR = 1.00, 95% CI: .80-1.25; OR = 1.16, 95% CI: .93-1.44, respectively).
Conclusions: Sex differences in auditory hallucinations are seen in both adult and youth populations. The higher rates of auditory verbal hallucinations seen in girls may be secondary to the differences in the rate of depressive symptoms.

Key words: hallucination, sex differences, adolescents, general population

Strengths and limitations of this study:

- The study investigated sex differences in the prevalence of auditory verbal hallucinations (AVH) in early, middle and late adolescence.
- Data were collected from a large general adolescent population, with high response rates.
- The study sample was one of the largest used for this topic.
- The study employed a cross-sectional design, hampering inferences about causal relationships based on cross-sectional associations.

Introduction:

Auditory verbal hallucinations (AVH) are experienced not only by patients with psychotic disorders, but also those with nonpsychotic psychiatric disorders and a substantial part of the general population.[1] Recent meta-analyses and systematic reviews reported that 5–9% of the general adult population have experienced AVH[1 2] and a median prevalence of psychotic symptoms (predominantly hearing voices) to be at 17% in a general childhood sample (aged 9–12 years) and 7.5% in adolescent samples (aged 13–18 years).[3] The question on AVH, rather than visual hallucination and persecutory thought, was very predictive of interview-verifiable psychotic symptoms and useful for screening on the general population.[4]

AVH often co-occur with depressive disorders among young people in clinical settings,[5] and are associated with internalising problems among children in community settings.[6] The presence of AVH also increases the risk of developing a wide range of psychiatric disorders and suicidal behaviour later in life.[7 8] AVH in the general population are most prevalent during adolescence, which is a critical window of vulnerability for the onset of psychosis.[9]

Previous studies have investigated sex differences in the prevalence of AVH among adolescents; however, the results are controversial. A meta-analysis showed that men are at a higher risk of the onset of psychotic disorders.[10] However, among person with psychosis and with clinical high risk status, women tend to experience more auditory hallucinations than men.[11 12] In general adult populations, women have a higher incidence of positive psychotic symptoms,[13] specifically auditory hallucinations,[14 15] compared to men. This sex difference may be mediated by depressive symptoms.[13 15] Similarly, girls report slightly more hallucinations than boys do.[16] In contrast, Kelleher et al. reported that (non-specified) psychotic symptoms are typically more prevalent among mid-adolescent boys than among girls;[17] however, these studies had a limited sample size. Recently, a large population-based survey of 9,646 Norwegian adolescents reported that being a woman was significantly associated with a higher prevalence of AVH, and that the difference was mediated by affective symptoms.[18] However, the age range of that study sample was 16–19 years. No study has investigated sex differences in the prevalence of AVH from early to late adolescence in a large population-based survey.

Therefore, we investigated sex differences in the prevalence of AVH among early, middle, and late adolescents using data from a large population-based survey of 17,451 Japanese adolescents aged 12–18 years. We also explored the degree to which any differences in this regard could be explained by differences in the levels of depressive symptoms in each age group.

Methods:

2.1 Study design and procedure

We employed an anonymous, cross-sectional survey in Japan with adolescents from public junior high schools (grades 7–9, age range = 12–15 years) and public senior high schools (grades 10–12, age range = 15–18 years). The survey was conducted between 2008 and 2009, using a self-reported questionnaire. The principal investigators asked all heads and administrators of public junior high schools in Tsu, Mie Prefecture, and public junior high and senior high schools in Kochi Prefecture to participate. Of the 138 junior and 36 senior high schools invited, 47 (34%) and 30 (83%) participated, respectively.

Parents were informed of the research project by letter and asked to notify the school if they did not want their children to participate. On the day of the survey, the students were also given the choice of opting out. Each teacher reported the number of students present and absent on the day of the survey. This study was approved by the ethics committees of the Tokyo Metropolitan Institute of Medical Science, Mie University School of Medicine, and Kochi Medical School.

2.2 Participants

In total, 19,436 students were recruited. Among those, 798 were absent on the day of the survey, 388 declined to participate, and 18,250 agreed to. Among those agreeing, 799 were excluded from the analysis because of incomplete answers to the questions regarding psychotic-like experiences. Therefore, responses from 17,451 students (aged 12–18 years, M_{age} = 15.2 years (standard deviation (SD) = 1.7), 50.6% girls) were analysed (valid response rate = 89.8%). Table 1 shows the adolescent groups by age and sex.

2.3 Measures

Participants were asked to complete an anonymous, self-reported questionnaire including questions about age, sex, and the following variables:

AVH

AVH were assessed through one of four items adopted from the schizophrenia section of the Diagnostic Interview Schedule for Children (DISC-C).[19] A Japanese version of the DISC-C was developed using a translation and back-translation method and has already been used in several previous studies conducted in Japan.[20-24] AVH were assessed with the item, 'Have you ever heard voices that other people cannot hear?' Answers were provided on the following three-point scale: '*no*', '*maybe*', and '*yes, definitely*'. In addition, we asked participants if they had experienced AVH within the last six months. We defined adolescents who answered '*yes, definitely*' and those who had experienced AVH within the last six months as those who had experienced AVH, and all the others as those who had not experienced AVH.

Depressive symptoms

Depressive symptoms were assessed using a 12-item General Health Questionnaire (GHQ-12). The GHQ-12 is one of the most widely used self-report measures for assessing depression.[25] It has been used and validated in younger samples, as well as in adults.[26] In addition, previous studies have established the validity and reliability of the Japanese version of this instrument.[27] A four-point scale recorded into binary scoring (0-0-1-1) was used for the GHQ's 12 items. Responses for each question were added together to form a total score ranging from 0 (best possible) to 12 (worst possible).

2.4 Statistical Analysis

We examined the effect of sex differences on the prevalence of AVH, using multivariate logistic regression. We initially tested the interaction effect between sex and age on the prevalence of AVH, to determine if the effect of sex was modified by age. Then, we calculated the odds ratio (OR) of the effect of sex differences on the prevalence of AVH. In addition to the crude OR, we calculated the adjusted OR after adjusting for depressive symptoms. The significance level was set to $p < .05$. All statistical analyses were conducted using the IBM Statistical Package for Social Sciences (SPSS), version 21.0 for Windows (IBM Corp, New York, USA).

Results:

3.1 Prevalence of AVH and depressive symptoms

The prevalence of AVH within six months was 5.7% among adolescents: 7.0% in early adolescence (aged 12–13 years), 6.2% in middle adolescence (aged 14–15 years), and 4.8% in late adolescence (aged 16–18 years). The GHQ-12 scores were 2.9 (SD = 3.0), 3.4 (SD = 3.1), and 3.9 (SD = 3.2) in early, middle, and late adolescence, respectively. Adopting the validated cut-off value of 3/4, the prevalence of depression was 34.3% in early adolescence, 41.5% in middle adolescence, and 49.5% in late adolescence.

3.2 Sex differences in the prevalence of AVH in early, middle, and late adolescence

The prevalence of AVH within the past six months was higher among girls than boys (chi-square = 38.1, df = 1, p < .001). AVH prevalence within six months, by sex and age group is shown in Figure 1. Since the interaction effect between sex and age on AVH prevalence was significant (p < .001), we conducted logistic regression analyses on each of the three age groups. Being female was significantly associated with a higher prevalence of AVH in all three age groups (early adolescence: OR = 1.71, 95% confidence interval (CI): 1.31–2.23; middle adolescence: OR = 1.42, 95% CI: 1.14–1.76; and late adolescence: OR = 1.52, 95% CI: 1.23–1.87) (Table 2).

3.3 Sex differences in the prevalence of AVH and depressive symptoms

After adjusting for depressive symptoms, the influence of sex differences on the prevalence of AVH did not remain significant for any of the three age groups (early adolescence: OR = 1.21, 95% CI: .92–1.60; middle adolescence: OR = 1.00, 95% CI: .80–1.25; and late adolescence: OR = 1.16, 95% CI: .93–1.44) (Table 2).

Discussion:

This was the first study to investigate sex differences in the prevalence of AVH through early, middle, and late adolescence in a large population-based survey. The results revealed that sex differences in AVH that have been observed in general adult populations are also observed among adolescents. The effect of sex was greater in early than it was in middle or late adolescence. However, for all age groups, a higher prevalence of AVH in girls may be secondary to differences in depressive symptoms.

The prevalence of AVH within the last six months (5.7%) was comparable to that in previous results.[17 18] Prevalence was higher in early adolescence than it was in late adolescence. This was in line with previous findings that showed that the prevalence of psychotic experiences decreases with age during adolescence.[17]

The prevalence of AVH was higher among female adolescents than it was among males in all three stages of adolescence. However, being female was more strongly associated with an increased prevalence of AVH in early adolescence than it was in middle to late adolescence. Moreover, the effect of being female on the prevalence of AVH did not remain after controlling for the GHQ score.

Bidirectional associations between AVH and depressive symptoms may be hypothesized. Adolescents with AVH may be more distressed because of their AVH; on the other hand, depressive symptoms may make adolescents more vulnerable to psychotic experiences. Adverse experiences (e.g. child abuse) may be underlying the association between AVH and depression, as noted in a previous review.[5] Women with psychosis have proven more likely to report abuse experiences during childhood and adolescence.[28] Those with adverse experiences are more prone to internalising difficulties, compared to men.[29] Taken together, there may be a differential interaction of early trauma with biological factors (e.g. genetic variations, hormonal factors) between men and women. In studies, adolescent girls were more vulnerable to hypothalamic-pituitary-adrenal axis dysregulation, compared to boys,[30] in particular after exposure to child abuse,[31] which potentially led to depression[30] and psychotic symptoms at a later stage.[32 33] Unfortunately, our cross-sectional data would not allow any further differentiation in causal relationships.

Several limitations of our study should be noted. First, information was not available about further confounding factors that may be associated with AVH, such as socioeconomic status, family circumstances, abuse history, personality disorders, or substance abuse. Second, although we had good compliance among high school students (83%) in Kochi Prefecture, we could not achieve the same levels of participation in junior high schools in Tsu City and Kochi Prefecture, where only 47 (34%) of the 138 junior high schools agreed to participate. This was because of refusal by the Educational Committee in Kochi Central City, which supervises most junior high schools in our targeted regions. Lastly, as noted above, we used a cross-sectional sample; therefore, we could not identify causal relationships between sex, depressive symptoms, and AVH. Follow-up studies are needed to address these issues.

Despite these limitations, this study has significant strengths. First, this was one of the largest studies to date to examine the prevalence of psychotic experiences among adolescents. Second, we examined this phenomenon

through three distinct stages of adolescence, enabling us to examine the effect of sex and depressive symptoms across different age ranges.

This study has some practical implications. Teachers and specialists in adolescent mental health are advised to be warier of both hallucinatory experiences and depressive symptoms among adolescents. AVH are more prevalent than earlier believed and are more frequent among girls than they are among boys. Understanding this may allow teachers and specialists to more effectively identify and help those in distress.

Figure legends:

Figure 1. Prevalence of auditory hallucinations by sex and age group

Authors' contributions:

YMorokuma, KE, AN, SY, SA, YMorimoto, MN, YO, TAF, SM, and SS conceptualized the study. YMorokuma, KE, AN, SY, TAF, and SS wrote the first draft of the manuscript. YMorokuma, KE, AN, and SY conducted the statistical analyses. SY, SS, and AN helped in the design of the study and the management of the database. SS and AN managed the survey process in the field. All authors contributed to and have approved the final manuscript.

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Competing interests:

None.

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Data sharing statement:

This study was planned and conducted in accordance with the ethics committee of the Tokyo Metropolitan Institute of Medical Science. When applying to the research ethics committee for our data set, we did not request for its release as public data. However, the data can be made available to all interested researchers upon request to Syudo Yamasaki, PhD.

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Table 1. Age and sex breakdown of the 17,451 adolescents

Age (years)	Male, n (%)	Female, n (%)	Total, n
12–13	1,826 (52.0)	1,687 (48.0)	3,513
14–15	2,956 (50.3)	2,920 (49.7)	5,876
16–18	3,838 (47.6)	4,224 (52.4)	8,062
Total	8,620 (49.4)	8,831 (50.6)	17,451

Table 2. Logistic regression for sex differences in predicting auditory hallucination.

	Unadjusted model			Adjusted model [a.]		
Age (years)	OR	95% CI	p	OR	95% CI	p
12–13	**1.71**	**(1.31–2.23)**	**<.001**	1.21	(.92–1.60)	.178
14–15	**1.42**	**(1.14–1.76)**	**.001**	1.00	(.80–1.25)	.983
16–18	**1.52**	**(1.23–1.87)**	**<.001**	1.16	(.93–1.44)	.188

OR: odds ratio; CI: confidence interval.

a. Adjusted for depressive symptoms assessed using GHQ-12 scores

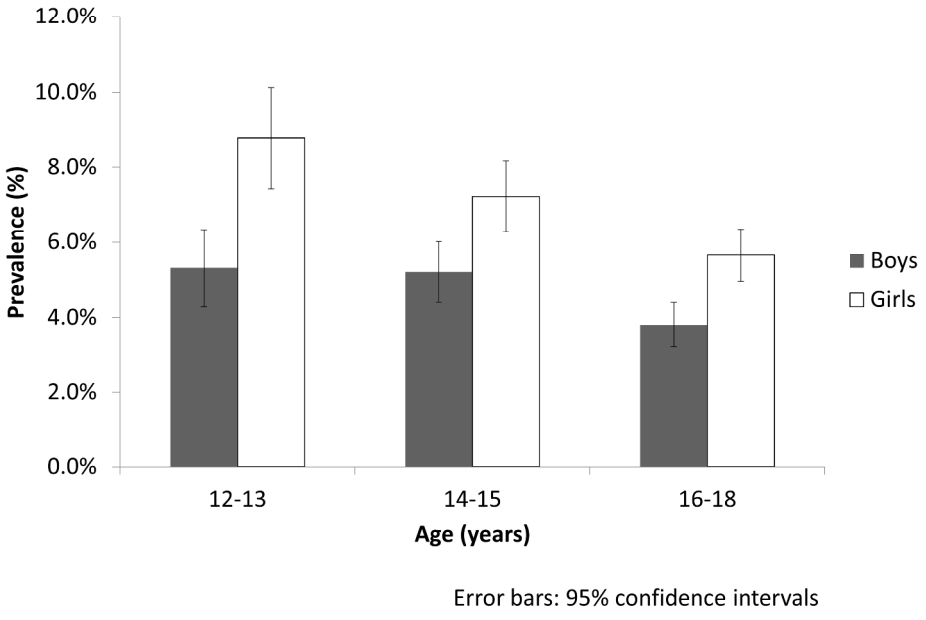

Figure 1. Prevalence of auditory hallucinations by sex and age group

254x190mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) 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	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	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	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	5,6
Bias	9	Describe any efforts to address potential sources of bias	5
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	5,6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) 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	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7,12
		(b) Indicate number of participants with missing data for each variable of interest	-
Outcome data	15*	Report numbers of outcome events or summary measures	7,12
Main results	16	(*a*) 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	7, 13,14
		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
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	8

Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
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	9

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.