Association between suicidal behaviors and auditory and visual hallucinations in Japanese adolescent psychiatric outpatients at first visit: a cross-sectional study

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Background: Suicide remains one of the leading causes of death among adolescents. Although recent studies have suggested a strong association between auditory hallucinations and suicidal behaviors, little is known regarding the association between suicidal behaviors and visual hallucinations, which are also common among adolescent psychiatric patients. **Method:** A cross-sectional study of all first-time patients aged 10–15 years was conducted at three child and adolescent psychiatric outpatient facilities in Kanagawa Prefecture, Japan, from April 2015 to March 2018. Self-reported questionnaires were administered to evaluate auditory and visual hallucinations, suicide planning, and suicide attempts within the two weeks prior to the first visit. Our logistic regression model included three covariates (sex, age, and presence of major depressive episode) for adjustments. Among the 1285 respondents, 37 who had moderate or severe intellectual disability were excluded, leaving 1248 for analysis. **Results:** Among the 1069 patients who completed questionnaire items on hallucinations, 230 (21.5%) experienced auditory or visual hallucinations. After controlling for all confounders, visual hallucinations, but not auditory hallucinations, were significantly associated with increased odds of suicide planning (odds ratio [OR] 2.5, 95% confidence interval [CI] 1.5–4.1). In contrast, auditory hallucinations, but not visual hallucinations, were significantly associated with increased odds of suicide attempts (OR 2.8, 95% CI 1.3–6.1). No interaction effects were observed between suicidal behaviors and auditory or visual hallucinations. **Conclusions:** Clinicians should consider the prevalence of both auditory and visual hallucinations among young adolescent patients, with emphasis on auditory hallucinations, given their association with suicide attempts.

Key Practitioner Message

- Hallucinations are common among adolescent psychiatric patients.
- Auditory hallucinations were associated with suicide attempts, whereas visual hallucinations were associated with suicide planning, a precursor of suicide attempts.
- Clinicians should be aware that auditory hallucinations, among other hallucinations, could increase the risk of suicide.

Keywords: Adolescent; suicide; hallucinations; psychotic disorder

Introduction

Suicide remains one of the leading causes of death among the youth worldwide (WHO, 2021). To prevent suicide among young people, identifying those at risk is imperative (Reinherz, Tanner, Berger, Beardslee, & Fitzmaurice, 2006). However, psychological and contextual factors that lead young people from suicide planning to actual suicide attempts still remain unclear (Miranda & Shaffer, 2013).

Despite the importance of focusing on psychotic symptoms in improving knowledge on suicidal behaviors among adolescents, recent research has demonstrated a strong association between suicidal behaviors and

psychotic symptoms among both non-clinical and clinical adolescent populations (Kelleher et al., 2013, 2014). Psychotic symptoms have been associated with increased odds of suicidal behaviors regardless of comorbid mental disorders (Yates et al., 2019). Hallucinations, which are erroneous percepts in the absence of identifiable stimuli, are characterized by various psychotic symptoms, including delusions, confusion, and disturbed thoughts in adolescents (Granö et al., 2016; Laurens, Hobbs, Sunderland, Green, & Mould, 2012). Current evidence has shown that hallucinations in children and adolescents occur on a continuum from health to psychopathology-related phenomena. Hallucinations are often multimodal, with auditory, visual, tactile, olfactory, and gustatory hallucinations having been documented (Chouinard et al., 2019). In particular, previous studies showed an association between auditory hallucinations and self-harm behaviors, emotional disturbance, cognitive biases, low self-esteem, and traumatic life events, such as sexual assault or bullying (Hielscher et al., 2020; Maijer et al., 2019).

Hallucinations can be classified under the two categories of auditory and nonauditory hallucinations, with visual hallucinations among adolescents forming part of the latter (Grano et al., 2015; Yoshizumi, Murase, Honjo, Kaneko, & Murakami, 2004). A previous study on symptomatology suggested that hallucinations cannot be considered a homogeneous entity but rather as distinct modalities (Galletti, Paolini, Tortorella, & Compton, 2017).

Presently, limited knowledge is available regarding the association between suicidal behaviors and auditory and visual hallucinations among adolescents due to the paucity of studies on both auditory and visual hallucinations simultaneously. Previous studies have indicated a strong association between auditory hallucinations and suicide attempts (Fujita et al., 2015; Maijer et al., 2019). The only study that simultaneously examined both auditory and visual hallucinations reported that suicidal ideation was not significantly associated with the former but was significantly clinically associated with the latter in adolescent outpatients (Grano et al., 2015), suggesting that auditory and visual hallucinations may be associated differently with suicidal ideation. However, whether these hallucinations are related to other suicidal behaviors, such as suicide planning and suicide attempt, remains unclear. Moreover, coexisting auditory and visual hallucinations may have a stronger effect on suicidal behaviors. Indeed, a previous study revealed that coexisting auditory and visual hallucinations indicated greater psychopathology and less favorable prognosis in patients with psychotic disorders (Clark, Waters, Vatskalis, & Jablensky, 2017). However, the synergistic effect of auditory and visual hallucinations on suicidal behaviors among adolescent patients remains unclear. Further research is needed to examine the possible relationship between auditory and/or visual hallucinations and suicidal behaviors.

The current study sought to clarify the association between suicidal behaviors and auditory and visual hallucinations in adolescent outpatients during their first visit. The following hypotheses were established: (a) visual and auditory hallucinations would be prevalent; (b) auditory and/or visual hallucinations would be differently associated with either suicide planning or attempt; and (c) the combination of auditory and visual hallucinations would have synergistic effects on suicidal behaviors. This study separately examined the main effects of auditory and visual hallucination and the interactions of both types of hallucinations for two specific suicidal behaviors, namely suicide planning and suicide attempt.

Methods

Subjects and procedures
This cross-sectional study was conducted at three outpatient clinics in Yokohama City, Kanagawa Prefecture, Japan. Subjects included first-time psychiatric referrals aged 10–15 years who visited the Yokohama City University Hospital or Yokohama City University Medical Center between April 2015 and March 2018 (36-month timeframe) or Kanagawa Children's Medical Center between April 2017 and March 2018 (12-month timeframe). A total of 1285 first-time patients, 506 from Yokohama City University Hospital, 418 from Yokohama City University Medical Center, and 361 from Kanagawa Children's Medical Center were identified during the study period.

Participants were recruited using consecutive sampling. Self-report questionnaires were routinely provided to first-time referrals to assess mental health status. All patients were requested to complete the self-reported questionnaires prior to routine clinical interview. Each patient was diagnosed by experienced psychiatrists established based on the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10), (WHO, 2015).

To ensure data reliability from self-report questionnaires, 37 patients with moderate, severe, or profound intellectual disability were excluded from the study. Intellectual disability was assessed either by adaptive functioning, such as welfare services status, or by intelligence quotient scores at the initial visit.

This study was approved by the ethics committees of Yokohama City University (B181100008, 7th December 2018) and Kanagawa Children's Medical Center (102-06, 2nd March 2017), Yokohama City, Japan. Although the need for informed consent was waived by the ethics committees, patients and their families were informed that they could decline to participate without compromising the medical care they would receive. None of the patients ultimately declined to participate.

Measures
The self-report questionnaire determined whether the following items were present or absent in the two weeks prior to their initial visit: (a) suicidal behaviors (suicide planning and suicide attempt); (b) auditory and visual hallucinations; and (c) major depressive episode. Data on demographic characteristics were collected from the medical records. Primary outcomes included suicide planning and suicide attempt.

Suicidal behaviors: suicide planning and suicide attempt
Dichotomous questions were used for current suicide planning and suicide attempts based on the Japanese translation of the Columbia Suicide Severity Rating Scale (Posner et al., 2011; Shiratori, Tachikawa, & Yamada, 2017).

The question regarding suicide planning was as follows: 'Over the last two weeks, have you worked out the details of how to kill yourself?' The question about suicide attempt was as follows: 'Over the last two weeks, have you ever done anything to end your life?' Respondents could answer with either 'yes' or 'no' to each question. Children who selected 'yes' were designated as having engaged in the corresponding behavior.

Auditory and visual hallucinations
The question regarding auditory hallucinations was as follows: 'Over the last two weeks, have you ever heard voices that other people could not hear?' The question for visual hallucinations

was as follows: 'Over the last two weeks, have you ever seen something or someone, such as a person, animal, or ghost, which other people could not see?' Both questions were based on a previous study on psychotic-like experiences among children (Laurens et al., 2012) and were answerable by 'yes' or 'no'. Those who answered 'yes' were designated as having experienced the corresponding hallucination. Although previous studies used a 3-point scale, dichotomous questions were used herein for simplicity so that very young patients need not hesitate to answer (Fujita et al., 2015; Laurens et al., 2012).

Major depressive episode

Given that depressive symptoms are a major risk factor for adolescent suicidal behaviors, we considered depression as a potential confounder (Hawton, Saunders, & O'Connor, 2012). The Japanese version of Patient Health Questionnire-9 (PHQ-9) was used to assess for major depressive episodes (Kroenke, Spitzer, & Williams, 2001; Muramatsu et al., 2018). Response categories included 'not at all', 'on several days', 'more than half of all days', and 'nearly every day', which were scored from 0 to 3, respectively. A PHQ-9 score ≥14 and <14 indicated major depressive episode and mild depressive episode or no symptoms, respectively, based on a previous study conducted in Japan (Inoue et al., 2012). A PHQ-9 score ≥14 was also confirmed to have a sensitivity and specificity of 72.2% and 94.0% for screening for major depressive disorder among Taiwanese adolescents, respectively (Tsai et al., 2014).

Demographic characteristics

Data on sex, age, and diagnosis of mental disorders were collected from the medical records. All diagnoses and corresponding codes focused at the beginning of this study were as follows: organic, including symptomatic, mental disorders (F00-09); mental and behavioral disorders due to psychoactive substance use (F10-19 in ICD-10); schizophrenia, schizotypal, and delusional disorders (F20-29); manic episode or bipolar affective disorder (F30-31); depressive disorder (F32-33); other affective disorder (F34-39); neurotic disorders (F40-48); eating disorders and other somatic disorders (F50-59); mental retardation (F70-79); pervasive developmental disorder (F84); and attention-deficit/hyperactivity disorder (F90).

Statistical analysis

The prevalence of suicide planning and suicide attempt, as well as other characteristics in relation to (a) presence of auditory hallucinations only, (b) presence of visual hallucinations only, (c) presence of both auditory and visual hallucinations, and (d) absence of hallucinations, was determined. Pearson's chi-square test of independence was used to compare the prevalence of suicide planning and suicide attempt in patients with or without each class of hallucination.

Associations between both primary outcomes (suicide planning and suicide attempt) and both primary explanatory variables (auditory and visual hallucinations) were evaluated using logistic regression analysis. The logistic regression model adjusted for three covariates (sex, age, and major depressive episode). The interaction term of the primary explanatory variables was also considered to estimate the main and interaction effects of auditory and visual hallucinations simultaneously. During regression analysis, multiple imputations by chained equations (MICE) assuming the presence of missing at random (MAR) predictors were employed to address missing predictors. Moreover, regression analysis was performed for sensitivity analysis in subjects with (a) no missing data (complete case analysis), and (b) imputed responses and predictors from MICE assuming the presence of missing not at random (MNAR) responses and MAR predictors. The flow diagram of samples for the analysis is shown in Figure 1.

All analyses were performed using SPSS version 23.0 (SPSS, IBM, Chicago, IL, USA) and R version 3.5.1 (R Foundation for Statistical Computing, Vienna, Austria) using the R packages 'MICE' (version 3.8.0; https://www.jstatsoft.org/v45/i03/; van Buuren & Groothuis-Oudshoorn., 2011) and 'miceMNAR' (version 1.0.2; https://cran.r-project.org/package=miceMNAR; Galimard & Resche-Rigon, 2018), with the level of significance set at α = 0.05.

Results

Demographic characteristics

A total of 1248 consecutive subjects [644 boys (51.6%)] with a mean age of 12.6 years (standard deviation, 1.6; test value, 274.2; degrees of freedom 1247; effect size, 1.0; $p < .01$) were analyzed. Among them, 567 (45.4%) and 681 (54.6%) were elementary (10–12 years) and junior high school-aged patients (13–15 years), respectively, while 7 (0.6%) were diagnosed with organic, including symptomatic, mental disorders (F00-09), 1 (0.1%) with mental and behavioral disorders due to psychoactive substance use (F10-19), 28 (2.2%) with schizophrenia and related disorders (F20-29), 0 (0.0%) with manic episode or bipolar affective disorder (F30-31), 78 (6.3%) with depressive disorder (F32-33), 11 (0.9%) with other affective disorder (F34-39), 453 (36.3%) with neurotic disorders (F40-48), 116 (9.3%) with eating disorders and other somatic disorders (F50-59), 58 (4.6%) with mild mental retardation (F70), 28 (2.2%) with specific developmental disorders of scholastic skills (F81), 272 (21.8%) with pervasive developmental disorders (F84), and 115 (9.2%) with attention deficit/ hyperactivity disorders. The demographic characteristics are summarized in Table 1. Among 246 patients with major depressive episode (PHQ-9 score ≥ 14), 31 (12.6%) had depressive disorder (F32-33), whereas 6 (2.4%) had other affective disorder (F34-39).

Overall, 179 patients (14.3%) hesitated to answer the questionnaires regarding hallucinations. Among the 1069 patients who completed the questionnaire items on auditory and visual hallucinations, 230 (21.5%) experienced hallucinations. In total, 158 (14.8%), 157 (14.7%), and 85 (8.0%) patients experienced auditory hallucinations, visual hallucinations, and both hallucinations, respectively.

Patients with psychotic disorders or major depressive episode (PHQ-9 score ≥14) had a significantly higher prevalence of auditory or visual hallucinations or both than those without the same (Table 1).

Prevalence and odds ratio for suicidal behaviors (suicide planning and suicide attempt)

The prevalence of suicide planning or suicide attempt in patients with any hallucinations among the 1014 patients who completed questionnaires for both of any suicidal behaviors and auditory–visual hallucinations are detailed in Table 2. Accordingly, patients with auditory hallucinations had a higher prevalence of suicide planning than those without the same (31% vs. 11%, chi-squared distribution for single degree of freedom (SDOF), 39.0; $p < .01$). Similarly, those with visual hallucinations had a higher prevalence of suicide planning than those without the same (35% vs. 11%, chi-squared distribution for SDOF, 60.4; $p < .01$). Moreover, those with both auditory and visual hallucinations had a higher prevalence of suicide planning than those without the same (45% vs. 12%, chi-squared distribution for SDOF 61.2; $p < .01$). Those with auditory hallucinations had a higher prevalence of suicide attempt than those
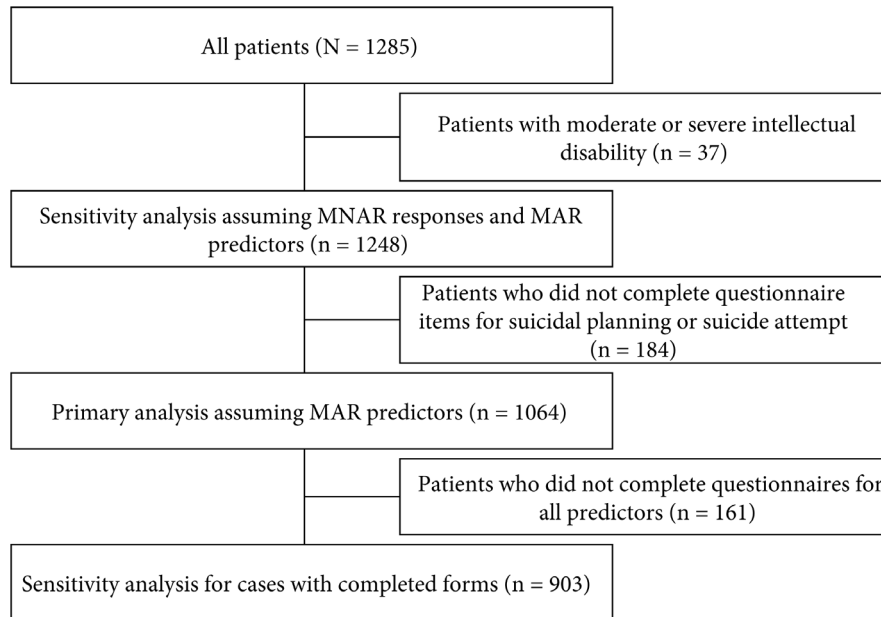
Figure 1. Flow diagram of the samples analyzed for sensitivity analysis. MAR, missing at random; MNAR, missing not at random

Table 1. Demographic and clinical characteristics of the patients included herein according to the presence or absence of auditory and visual hallucinations

	Total n (%)	Auditory hallucinations[b]			Visual hallucinations[c]			Both hallucinations[d]		
		Any n (%)	None n (%)	p*	Any n (%)	None n (%)	p*	Any n (%)	None n (%)	p*
Total number	1248	158	918		159	920		85	984	
Sex										
Boys	644 (51.6)	78 (49.4)	473 (51.5)	.67	74 (46.5)	477 (51.8)	.21	36 (42.4)	511 (51.9)	.11
Age										
10–12 years	567 (45.4)	68 (43.0)	412 (44.9)	.73	71 (44.7)	407 (44.2)	.93	39 (45.9)	438 (44.5)	.82
13–15 years	681 (54.6)	90 (57.0)	506 (55.1)		88 (55.3)	513 (55.8)		46 (54.1)	546 (55.5)	
Diagnosis of mental disorder (ICD-10)										
Psychotic disorder (F20-29)	28 (2.2)	11 (7.0)	12 (1.3)	<.01	15 (9.4)	9 (1.0)	<.01	10 (11.8)	13 (1.3)	<.01
Mood disorder (F30-39)	89 (7.1)	14 (8.9)	67 (7.3)	.51	14 (8.8)	69 (7.5)	.52	7 (8.2)	74 (7.5)	.83
Neurotic, stress-related and somatoform disorders (F40-48)	453 (36.3)	64 (40.5)	339 (36.9)	.42	350 (38.0)	58 (36.5)	.72	33 (38.8)	369 (37.5)	.82
Pervasive developmental disorders (F84)	272 (21.8)	32 (20.3)	202 (22.0)	.68	39 (24.5)	195 (21.2)	.35	18 (21.2)	215 (21.8)	1.00
Attention deficit hyperactivity disorders (F90)	115 (9.2)	9 (5.7)	91 (9.9)	.10	13 (8.2)	86 (9.3)	.78	6 (7.1)	92 (9.3)	.69
Learning disorder (F81)	28 (2.2)	5 (3.2)	20 (2.2)	.38	1 (0.6)	25 (2.7)	.16	1 (1.2)	24 (2.4)	.72
Mild mental retardation (F70)	58 (4.6)	39 (4.2)	6 (3.8)	1.00	39 (4.2)	5 (3.1)	.67	2 (2.4)	42 (4.3)	.57
Major depressive episode (PHQ-9 score ≥ 14)[a]	246 (27.0)	77 (54.6)	167 (20.6)	<.01	74 (51.4)	171 (21.2)	<.01	46 (59.7)	198 (22.8)	<.01

ICD-10, International Statistical Classification of Disease, 10th Revision; PHQ-9, Patient Health Questionnaire 9.
*p, p value for difference in prevalence between none and any hallucinations based on Pearson's chi-square test.
[a]Excluding 284 participants for whom data on major depressive episode were not collected.
[b]Excluding 172 participants for whom data on auditory hallucinations were not collected.
[c]Excluding 169 participants for whom data on visual hallucinations were not collected.
[d]Excluding 179 participants for whom data on both auditory and visual hallucinations were not collected.

without the same (15% vs. 3%, chi-squared distribution for SDOF, 42.1; $p < .01$). Similarly, patients with visual hallucinations had a higher prevalence of suicide attempt than those without the same (14% vs. 3%, chi-squared distribution for SDOF, 31.0; $p < .01$). Moreover, those with both auditory and visual hallucinations had higher suicide attempt prevalence than those without

the same (21% vs. 3%, chi-squared distribution for SDOF, 48.5; $p < .01$).

Regression analysis for suicide planning was initially performed to estimate the main and interaction effects of auditory and visual hallucinations simultaneously, in which MICE was used. Accordingly, the presence of visual hallucinations was found to be associated with

Table 2. Prevalence and odds ratio for suicidal behaviors in adolescents with auditory hallucinations, visual hallucinations, or both

| | | Odds ratio[b,c] | | | |
| | | Model 1 | | Model 2 | |
Prevalence[a]	Suicide planning	OR (95%CI)	p	OR (95%CI)	p
With auditory hallucinations (n = 138)*	43 (31.2%)	1.4 (0.8–2.4)	.21	1.1 (0.6–2.3)	.73
With visual hallucinations (n = 139)*	49 (35.3%)	2.5 (1.5–4.1)*	<.01	2.1 (1.1–4.1)*	.03
With both (n = 71)*	32 (45.1%)			1.6 (0.6–4.6)	.39
	Suicide attempt				
With auditory hallucinations (n = 138)*	21 (15.2%)	2.8 (1.3–6.1)*	<.01	2.3 (0.8–6.4)	.11
With visual hallucinations (n = 139)*	19 (13.7%)	1.8 (0.9–3.8)	.11	1.4 (0.4–4.3)	.57
With both (n = 71)*	15 (21.1%)			1.7 (0.4–7.7)	.52

95%CI, 95% confidence interval; MAR, missing at random; OR, odds ratio.
Model 1: age, sex, major depressive episode; auditory and visual hallucinations were simultaneously entered.
Model 2: age, sex, major depressive episode; auditory and visual hallucinations, and the combination of both, were simultaneously entered.
p, p value for regression analysis.
[a]Excluding 234 patients for whom data on both any suicidal behaviors and auditory/visual hallucinations were not collected.
[b]Regression analysis was performed using multiple imputations by chained equations assuming the presence of MAR predictors.
[c]Excluding 184 patients for whom data on suicide planning or suicide attempt were not collected.
*$p < .05$.

increased odds for suicide planning [odds ratio (OR) 2.5, 95% confidence interval (CI); 95% CI 1.5–4.1, $p < .01$]. However, the presence of auditory hallucinations and the combination of auditory and visual hallucinations were not associated with a significant change in the odds for suicide planning, even after controlling for potential confounders.

Complete case analysis showed that the presence of auditory (OR 2.1, 95% CI 1.3–3.5, $p < .01$) and visual hallucinations (OR 3.3, 95% CI 2.1–5.3, $p < .01$) was associated with increased odds for suicide planning. MICE assuming the presence of MNAR responses and MAR predictors also showed that the presence of visual hallucinations was associated with increased odds for suicide planning (OR 1.7, 95% CI 1.2–2.3, $p < .01$) (Table S1).

Regression analysis for suicide attempt was thereafter performed to estimate the main and interaction effects of auditory and visual hallucinations simultaneously. Regression analysis was performed using MICE assuming the presence of MAR predictors. Accordingly, the presence of auditory hallucinations was associated with increased odds for suicide attempt (OR 2.8, 95% CI 1.3–6.1, $p < .01$). However, the presence of visual hallucinations and both auditory and visual hallucinations was not associated with a significant change in the odds for suicide attempts, even after controlling for potential confounders.

Complete case analysis showed that the presence of auditory (OR4.1, 95% CI 2.0–8.5, $p < .01$) and visual hallucinations (OR2.4, 95% CI 1.1–5.0, $p = .02$) was associated with increased odds for suicide attempt. MICE assuming the presence of MNAR responses and MAR predictors showed that the presence of auditory hallucinations was also associated with increased odds for suicide attempt among patients (OR 1.8, 95% CI 1.1–2.8, $p = .01$) (Table S1). ORs for suicide planning and suicide attempts are summarized in Table 2.

Discussion

The current study revealed new and potentially important information regarding suicidal behaviors among adolescent patients with hallucinations using a larger sample compared with our previous study (Fujita et al., 2015). To the best of our knowledge, this is the first study to investigate the main and interaction effects of auditory and visual hallucinations with regard to suicide planning and suicide attempt among adolescent patients.

The main findings of this study are threefold. First, almost one-fifth of the adolescent patients experienced auditory or visual hallucinations. Second, the presence of visual hallucinations, but not auditory hallucinations, was significantly associated with increased odds for suicide planning. Conversely, the presence of auditory hallucinations, but not visual hallucinations, was associated with increased odds for suicide attempt. Third, no interaction effect between auditory and visual hallucinations and suicidal ideation or suicide attempt had been observed. Our hypothesis was partially proven by these results. Both auditory and visual hallucinations were relatively common, and each hallucination was associated with either suicide planning or suicide attempts. However, a combination of auditory and visual hallucinations had no synergistic effects on suicidal behaviors.

Hallucinations among adolescent patients should not be overlooked. This study showed that a certain subset of adolescents with non-psychotic and psychotic disorders presented with auditory and visual hallucinations. Although many of these hallucinations are often transient, some adolescents experience considerable distress due to hallucinations (Maijer et al., 2019).

The presence of auditory hallucinations has been associated with suicide attempt among adolescent patients (Fujita et al., 2015; Thompson et al., 2020). Additionally, findings from our study suggest that auditory hallucinations in adolescent patients might have a stronger effect on suicidal actions compared with visual hallucinations. A previous study revealed that patients who appraise their auditory hallucination as powerful, impulsive, or malevolent can easily comply with such to do harm (Bucci et al., 2013). Adolescent patients might

take their own lives to relieve or nullify their painful distress, such as fear, depression, anxiety, and bodily effects resulting from these auditory hallucinations (Baumeister, Sedgwick, Howes, & Peters, 2017; Woods, Jones, Alderson-Day, Callard, & Fernyhough, 2015). Previous studies have supported the association between inhibitory control and auditory hallucinations (Badcock & Hugdahl, 2014), as well as the association between cognitive bias, such as emotional reasoning, and auditory hallucinations (Daalman, Sommer, Derks, & Peters, 2013). Lowered inhibition and negative cognition in adolescent patients may be important factors that characterize the relationship between auditory hallucinations and suicidal behavior. In contrast, associations between visual hallucinations and suicidal behaviors have remained unclear. Although previous studies have revealed associations between visual hallucinations and severe psychopathologies among patients with psychotic disorders (Chouinard et al., 2019; Clark et al., 2017), limited knowledge regarding visual hallucinations has been available, except that they are highly prevalent and often coexist with other psychopathologies, such as psychotic disorders, depression, and anxiety in child and adolescent populations (David et al., 2011; Yoshizumi et al., 2004). Only one study on adolescents had reported that visual hallucinations were independently associated with suicidal ideation, even after controlling for other psychotic symptoms, including auditory hallucinations (Grano et al., 2015). However, that study was unclear regarding the association between visual hallucinations and suicidal behaviors other than with suicidal ideation. The findings presented herein, however, help to clarify previously unclear associations between visual hallucinations and suicidal behaviors, although the reason for the seemingly different effects of auditory or visual hallucinations on suicidal behaviors remains obscure. Future studies that elucidate a theoretical model for auditory and visual hallucinations and suicidal behaviors among adolescents are warranted.

Although a previous study has indicated that hallucinations have additive effects on suicidal behaviors among clinical populations (Clark et al., 2017), to the best of our knowledge, no study has proven the synergistic effects of hallucinations on suicidal behaviors. A recent study examining the enhanced top–down processing of people with auditory hallucinations found that the presence of visual hallucinations did not affect expectation-based misperceptions among those with auditory hallucinations (de Boer et al., 2019). This information indicates that auditory and visual hallucinations may have distinct mechanisms in affecting the patient's perception of the external world. Based on the findings presented herein, the presence of visual hallucinations may not affect the association between auditory hallucinations and suicide attempts.

This study has several limitations. First, temporality and causality could not be concluded due to the cross-sectional design. The results only demonstrate a relationship between these two symptoms. Auditory or visual hallucinations may result in a risk for suicidal behaviors. As such, longitudinal studies to explore the risk factors for suicide attempt among patients with suicidal ideation or planning are vital. Second, auditory and visual hallucinations were not evaluated using comprehensive and systematic measures (Badcock &

Hugdahl, 2012; Maijer et al., 2019). Instead, the current study used single items to assess each hallucinatory experience. This is a major concern among studies on hallucination, with a recent review identifying variations in hallucinatory experiences among individuals or cultures (Pienkos et al., 2019). Moreover, dichotomous questions made it difficult to distinguish a categorical from a dimensional model considering auditory and visual hallucinations. In addition, the reliability and validity of PHQ-9 in assessing major depressive episodes and the Columbia Suicide Severity Rating Scale in assessing suicidal behaviors in Japanese adolescents have not been confirmed. Third, we did not confirm the content and quality of the hallucinations, such as omnipotence, malevolence, frequency, type, or source of hallucinations (Bucci et al., 2013; Woods et al., 2015). Fourth, although we considered major depressive episodes as a risk factor for suicidal behaviors, several other risk factors not measured in this study could have been present, including feelings of hopelessness, rumination, low self-esteem, duration of suicidal ideation, substance use, anxiety, or childhood adversity events such as bullying (Fialko et al., 2006; Miranda & Shaffer, 2013; Taylor, Hutton, & Wood, 2015).

Conclusion

Clinicians should be aware of the prevalence of visual and auditory hallucinations among young adolescent patients. Our finding of an association between auditory hallucinations and suicide attempt may be important for suicide prevention among young adolescent patients. Future research should therefore elucidate the association not only between auditory hallucinations and suicidal behavior but also between coexisting nonauditory hallucinations such as multi-sensory hallucinations.

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Ethical information

The study was approved by the ethics committee of Yokohama City University (B181100008, 7th December 2018) and the ethics committee of Kanagawa Children's Medical Center (102-06, 2nd March 2017).

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Supporting information

Additional Supporting Information may be found in the online version of this article:

Table S1. Odds ratio for suicidal behaviors determined by sensitivity analysis for complete cases or assuming MNAR responses and MAR predictors

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