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ORIGINAL PAPER

Association between psychotic experiences and non-accidental self-injury: results from a nationally representative survey of adolescents

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Abstract

Purpose The association between psychotic experiences (PEs) and non-accidental self-injury (NASI; including self-harm and suicide attempts) is well established, although variables influencing this relationship have not been comprehensively examined. This study aimed to investigate (1) the cross-sectional PE–NASI association before and after adjustment for confounders, and (2) the individual contribution of each confounding and potentially mediating variable to the association.

Methods A random sample of Australian adolescents aged 14–17 years ($n = 1998$) completed self-report questions regarding any self-harm, suicidality or PEs experienced in the past 12 months in 2013–2014 as part of the Young Minds Matter Survey, a national household survey. We conducted logistic regression analyses to investigate the association between NASI and PEs, after controlling for confounders (sociodemographics, substance use, and parental mental illness) as well as the influence of potential mediators (major depression, bullying, psychological distress, sleep, self-esteem, disordered eating behaviour, social isolation, and intervention factors).

Results Except for special messages, all PE subtypes (auditory and visual hallucinatory experiences [HEs], and two of the three delusional experiences [DEs]) were associated with NASI after adjustment for confounders (OR range: 2.60–5.21). Depression and psychological distress significantly influenced all PE–NASI associations, where depression appeared to fully explain the DE–NASI association, and partially attenuate the HE–NASI association. Variables such as parental mental illness, disordered eating behaviour, and social isolation had negligible effects in nearly all self-harm and attempted suicide models.

Conclusions Adolescents reporting any PE in the past 12 months reported increased likelihood of NASI in the same time period and, auditory HEs in particular, were strongly and independently associated with self-harm and suicide attempts. These results highlight the importance of PEs as indicators of risk of self-injurious behaviour among Australian youth.

Keywords Psychotic experiences · Self-injurious behaviour · Self-harm · Suicide · Adolescents

Introduction

Non-accidental self-injury (NASI), which encompasses all forms of deliberate self-injurious behaviour (e.g., non-suicidal self-injury, deliberate self-harm, and suicide attempts) [1, 2], is a key risk factor for later completed suicide [3],

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and yet, the reasons why young people engage in these behaviours remain poorly understood. Research to date has focused on validating models of emotional dysregulation which are thought to facilitate and maintain NASI [4]. However, these have failed to fully explain such behaviours in adolescents and young adults [5, 6] and there is a need to examine other psychological processes involved in NASI.

Psychotic experiences (PEs), which include both clinical symptoms (e.g., hallucinations and delusions) as well as subclinical/subthreshold experiences, have been consistently shown to be associated with NASI. Honings and colleagues [7] reported in their 21-study meta-analysis a threefold increased likelihood of self-injurious behaviours in those with any PE (OR 3.20; 95% CI 2.33–4.40). In a 2017 cross-national analysis of 33,370 respondents [8], the temporal association between PEs and later NASI was present across the lifespan, where the effect was strongest in the younger ages. The relationship between PEs and NASI is particularly strong during adolescence and young adulthood [9–11], an age at which both phenomena are most prevalent [12, 13]. More research is needed in this age group to understand the factors which explain this association.

There are three limitations commonly found in previous studies of the PE–NASI association. The first is that many studies do not use populations representative of the whole community, for example, of the two Australian studies [14, 15], one recruited a convenience sample of university students [14], whereas the other collected data from high school students attending Catholic or independent schools (where relative to the Australian population, the sample were more likely to live in metropolitan areas and live in higher socioeconomic families) [15]. Most previous studies have examined the PE–NASI association using only auditory hallucinations [9, 10] or by collapsing all types of PEs into one variable [15–19]. The few adolescent/young adult studies that have investigated different types of PEs (e.g., hallucinatory, persecutory ideation, and bizarre experiences) have found differential associations [14, 20, 21], suggesting that some PEs are more likely to be associated with NASI than others. Finally, there is a lack of a comprehensive and consistent approach to adjustment or consideration for third variables (confounders, mediators, and moderators). Hielscher and colleagues [1] reported that 30% of existing adolescent and adult PE–NASI studies did not control or account for any third variables of interest, and no study to date has included such factors as insufficient sleep or social isolation, both of which are strongly associated with PEs and NASI [22–25]. Honings et al.'s [7] review also highlights this issue, where assessing the influence of depression in their meta-analysis resulted in an attenuated (but significant) PE–NASI association for all outcomes except deliberate self-harm. It is possible that the PE–NASI association is explained entirely by third variables. Furthermore, identifying and assessing the influence of key confounders and mediators are important in understanding the mechanisms involved in the PE–NASI association which may in turn inform interventions to prevent self-injurious behaviour and completed suicides [9–11].

Using a nationally representative sample of adolescents, the aims of the current study were to investigate:

1. the association between PEs and NASI before and after adjustment for confounders; and
2. the individual contribution of each third variable (confounders, mediators) to the PE–NASI association.

Methods

Sample

The Young Minds Matter (YMM) survey is a national study of mental health and wellbeing of Australian children and adolescents aged 4–17 years, where data were collected between 31 May 2013 and 10 April 2014. The design, sampling, and survey interview methods are described extensively elsewhere [26, 27]. Briefly, the survey employed area-based random sampling with voluntary recruitment and consent of households in scope, where there was at least one child aged 4–17 years. One child was randomly selected for inclusion, where there was more than one eligible child in the household. The overall response rate to the survey was 55% with 6310 parents and carers of eligible households participating in the survey. Comparisons with 2011 Census data showed that the YMM sample was broadly representative of the overall Australian population in terms of major demographic characteristics [26].

Of the final participating sample of 6310 families with children aged 4–17 years, 2251 of the children were aged 14–17 years. Of these, 2004 (89%) completed the adolescent self-report questionnaire which assessed for PEs. The research protocol for the study was approved by the Australian Government Department of Health Human Research Ethics Committee, and The University of Western Australia Human Research Ethics Committee.

Measures

A self-report questionnaire was completed in the home by survey participants aged 11–17 years. Consenting participants completed the questionnaire in private using a tablet computer. All responses were confidential and not shared with the consenting parent. The questions about self-harm and suicidality were restricted to those young people aged 12–17 years, and PE questions were only asked of those aged 14–17 years ($n = 2004$). This sample was the focus of the current study.

Psychotic experiences

12-month hallucinatory experiences (HEs) and delusional experiences (DEs) were captured using five items from the Diagnostic Interview Schedule for Children (DISC-IV; [28]) psychosis module: auditory HEs, visual HEs, thoughts being read, receiving special messages, and feeling spied-upon (see Hielscher and colleagues [29] for wording of items). If participants responded 'Yes' to any of these questions, a follow-up question was asked: 'Did these experiences happen when you were taking drugs or drinking alcohol?' Participants were classified as endorsing PEs if they responded 'No' to this question. Three participants did not complete all the PE questions and, therefore, were excluded from the sample. In the parent or carer interview, three respondents reported that their child had been diagnosed with schizophrenia or other psychotic disorders. As the focus of the study was on PEs not reaching the clinical threshold for a psychotic diagnosis, we also excluded these participants, leaving a sample for analysis of 1998 adolescents.

Non-accidental self-injury

NASI is an umbrella term defined in accordance with the definition used in the WHO/EURO multicentre study on self-harm [30], as an act in which an individual deliberately initiates a non-socially or culturally sanctioned behaviour that, without intervention from others, will harm or injure their own body tissue [30, 31]. NASI does not assume or preclude suicidal intent, and as such, this definition encompasses self-injurious behaviour where suicidal intent may be either present (e.g., suicide attempts) or absent (e.g., non-suicidal self-injury). The YMM survey questions probed (1) lifetime and 12-month occurrence of non-suicidal self-injury or self-harm without intending to end one's life (e.g., 'Have you ever deliberately done something to cause harm or injury, without intending to end your own life?'), and (2) lifetime and 12-month occurrence of suicide attempts (e.g., 'Have you ever actually attempted suicide?'). For both self-harm and suicide attempts, the initial screening question included a 'Prefer not to say' option, in addition to the 'No' and 'Yes' response categories. Following Zubrick et al.'s [32, 33] approach, young people who selected this option were sequenced out of the item set (see further details in "Results").

Third variables of interest

As highlighted by Hielscher and colleagues [1], potential confounding and mediating factors have been inconsistently controlled or accounted for in previous studies of the PE–NASI association. This systematic review identified seven broad confounder/mediator categories (sociodemographics, mental disorders, substance use, environmental factors, psychological factors, intervention factors, and family history factors). The current study adjusted for or considered key third variables (of both NASI and PEs) in each of the seven categories. Sociodemographics included age and sex; mental health disorders/problems included meeting diagnostic criteria for major depressive disorder, as assessed using the adolescent self-report version of the DISC-IV, and symptoms of disordered eating behaviour (measured using questions from the Avon Longitudinal Study of Parents and Children, together with participants' self-reported BMI); substance use included lifetime use of cannabis or other illegal drugs; environmental factors included being bullied or cyber bullied in the past 12 months; psychological factors included psychological distress (Kessler Psychological Distress Scale [K10]) experienced in the past 4 weeks, and self-esteem (Adolescent Self-Esteem Questionnaire [ASQ], recoded into above [healthy self-esteem] vs. equal to or below cutoff of 17 [low self-esteem] [34]); intervention factors included mental health service use in the past 12 months; and family history factors included parental mental illness as reported in the parent or carer interview (see Online Resource 1 for further details on relevant YMM items). As outlined in Hielscher et al.'s [1] review, it is important to distinguish which variables are confounders vs. mediators as this will influence the overall approach and interpretation of analyses. In line with theory and the temporal precedence among variables (1), sociodemographics, substance use, and family history factors were considered confounders, whereas all other factors were considered potentially mediating variables in this study.

In addition to the seven categories, two other potential mediating variables (insufficient sleep and social isolation) were identified in Hielscher et al.'s [1] systematic review as having been associated with both PEs [22, 23] and NASI [24, 25]. To date, these have not been incorporated in studies examining the PE–NASI association. Usual hours of sleep on school or workdays were captured in the YMM survey ('How many hours of sleep do you usually get on [a school night/a night when you have work the next day]?'). National guidelines have defined insufficient sleep hours for adolescents to be less than 8 h per night [35]. Insufficient sleep (< 8 h per night) is associated with increased risk of suicide attempts after adjustment for sociodemographics and depressive symptoms [36], and therefore, the hours of sleep variable was recoded into below (insufficient) vs. equal to or above 8 h of sleep per night (sufficient sleep).

Social isolation was captured with a composite score [37] which included: self-reported number of friends; frequency per week of face-to-face contact with friends or non-co-resident relatives; frequency per week of online contact with friends/relatives; level of involvement per week in extracurricular activity; and perceived ability to rely on friends.

Ratings to each question were summed to produce a social isolation score (range: 0–5), with a higher score indicating greater isolation.

Statistical analysis

All analyses were conducted using Stata/IC 14. Survey data were weighted using the Stata svyset procedure to represent the full Australian population of 14–17 years accounting for sex, age, family size, household income, and deliberate oversampling of 16–17 years [27]. Survey estimates and associated confidence intervals (CIs) were calculated using the method of Taylor Series Linearisation [38].

The associations between PEs and NASI were examined using multiple logistic regression. For suicide attempts (which has a low prevalence), cross validation using Firth's bias adjustment was performed which presents a more accurate prediction of rare events (e.g., 20 cases in a sample of 1000) by applying a penalised maximum likelihood estimation [39]. All potential confounders (sociodemographics, substance use, and parental mental illness) were included in the final model (Model 1). Each variable represented a distinct construct (no correlation coefficient above 0.50), they were each associated with PEs and NASI, and there was no evidence of multicollinearity based on standard thresholds for the variance inflation factor, see Online Resource 2 for an exploration of each third variable and their associations with the independent variable (PEs), dependent variable (NASI), and each other.

To address the second study aim, examining the individual contribution of each variable to the PE–NASI association, all third variables of interest (confounders, mediators) were added one by one to the unadjusted (base) model. We used the change-in-point-estimate strategy [40] to determine to what extent each factor contributed to the explanation of the PE–NASI association. The percentage of the contribution of individual variables were computed according to the formula:

$$\Delta = \frac{\ln \mathrm{OR}_{\text{base model}} - \ln \mathrm{OR}_{\text{base model + third variable}}}{\ln \mathrm{OR}_{\text{base model}}} \times 100$$

A change of at least 10% [40] in the PE–NASI point estimate was considered a notable contribution to the association.

Results

The total sample ($n = 1998$) consisted of 51.5% males, the mean age was 15.5 (SE = 0.03; range = 14–17 years), and the majority (90.9%) were in school. Exposure to bullying, insufficient sleep, and parental mental illness were common, and each one present in almost 40% of participants. Those who declined to answer self-harm ($n = 149$ or 7.7%) and suicide attempt ($n = 111$ or 5.3%) questions were further excluded from their respective analyses; leaving $n = 1849$ for self-harm and $n = 1887$ for suicide attempt analyses. A sensitivity analysis of participants who responded 'Prefer not to say' to self-injury questions showed no significant difference on age, sex, psychological distress, and parental mental illness compared to those who responded 'Yes' to self-injury questions. However, non-responders to the self-injury questions had a significantly lower prevalence of major depression compared to yes respondents.

Prevalence of psychotic experiences and NASI

Lifetime and 12-month prevalence of self-harm was 13.0% (95% CI 11.6–14.6) and 9.8% (95% CI 8.5–11.2), respectively, while the lifetime and 12-month prevalence of suicide attempts were 3.7% (95% CI 3.0–4.7) and 2.9% (95% CI 2.2–3.8), respectively. 12-month prevalence of PEs ranged from 3.3% (95% CI 2.6–4.3) for special messages to 14.0% (95% CI 12.3–15.8) for auditory HEs, see Hielscher and colleagues [29] for a detailed examination of 12-month prevalence of PEs in this sample.

Association between psychotic experiences and NASI

Table 1 presents the association between 12-month PEs and NASI, both unadjusted and adjusted for confounders (sociodemographics, substance use, parental mental illness). Except for special messages, the associations between each PE subtype and self-harm and suicide attempts persisted after adjustment in Model 1. Of note, all associations which survived adjustment (see 12-month suicide attempt column of Table 1) remained significant after Firth's bias adjustment (OR range 1.22–1.88; data not shown). In addition, when compared across different adolescent stages (using the Breslow–Day test for homogeneity of ORs; see Online Resource 3), there were no significant differences ($p > 0.05$) between PE–NASI associations in middle (14–15) vs. late adolescence (16–17 years), except for the spied-upon–self-harm association.

Contribution of individual third variables

Table 2 presents the association between auditory HEs and NASI, with each third variable (confounders, mediators) entered individually into the unadjusted (or base) model. Major depressive disorder contributed to the largest change in the strength of the association, with a 26.3% reduction in the log of the odds ratio (or log OR) for self-harm and a 39.7% reduction for suicide attempts. Psychological distress,

Table 1 Association between psychotic experiences and non-accidental self-injury, unadjusted and adjusted for confounders

Independent variable	12-month self-harm, $n = 1849$						12-month suicide attempt, $n = 1887$					
	n	%	Unadjusted		Model 1[a]		*n*	%	Unadjusted		Model 1[a]	
			OR[b]	95% CI	OR[b]	95% CI			OR[b]	95% CI	OR[b]	95% CI
12-month auditory HEs	72	29.4	**4.87**	**[3.47–6.84]**	**4.14**	**[2.86–6.02]**	28	10.8	**6.12**	**[3.57–10.50]**	**4.77**	**[2.65–8.56]**
12-month visual HEs	49	26.3	**3.68**	**[2.50–5.42]**	**3.34**	**[2.15–5.19]**	23	11.3	**5.83**	**[3.22–10.55]**	**5.21**	**[2.61–10.39]**
12-month thoughts read	26	25.8	**3.21**	**[1.92–5.35]**	**2.60**	**[1.51–4.46]**	9	9.5	**3.76**	**[1.69–8.35]**	**2.64**	**[1.08–6.43]**
12-month special messages	14	19.7	**2.14**	**[1.11–4.13]**	1.81	[0.81–4.03]	6	8.0	**2.88**	**[1.20–6.92]**	2.03	[0.70–5.91]
12-month spied-upon	68	29.5	**4.90**	**[3.42–7.03]**	**4.18**	**[2.75–6.34]**	21	9.0	**4.35**	**[2.41–7.87]**	**3.02**	**[1.61–5.69]**
12-month any PE	109	22.6	**4.18**	**[3.07–5.68]**	**3.73**	**[2.68–5.18]**	32	6.4	**3.49**	**[2.02–6.05]**	**2.65**	**[1.47–4.78]**

n = unweighted number of respondents with 12-month self-harm or suicide attempts among those with each psychotic experience; % = weighted percentage of respondents with 12-month self-harm or suicide attempts among those with each psychotic experience

OR, odds ratio; 95% CI, 95% confidence interval; HEs, hallucinatory experiences in the past 12 months; PE, any psychotic experience in the past 12 months, i.e., auditory hallucinatory experiences, visual hallucinatory experiences, thoughts read, special messages received or spied-upon

Bold indicates significant odds ratio ($p < 0.05$)

[a]Model 1: adjusted for sociodemographics (age, sex), lifetime substance use (cannabis and other illicit substances), and parental mental illness

[b]Odds ratio comparing the groups with and without psychotic experiences (e.g., for the '12-month any PE' logistic regression, the reference group is no endorsement of any psychotic experience)

mental health service use, being bullied, and insufficient sleep also resulted in notable reductions (≥ 10%). Although these variables resulted in sizable attenuation, no single variable explained the association between auditory HEs and NASI, and in fact, the association remained significant after adjustment and consideration for all confounders and mediators in both the self-harm (OR 2.44; 95% CI 1.48–4.03) and attempted suicide model (OR 3.35; 95% CI 1.61–6.97).

The effects of age, sex, disordered eating behaviour, parental mental illness, and social isolation were negligible in both models. There were some differences between the two models, where substance use and low self-esteem resulted in a greater than 10% reduction in the log OR for suicide attempts, but not for self-harm.

The same change-in-point-estimate strategy was applied to the other PEs to investigate which factors contributed most to their associations (see Online Resource 4). For the association between self-harm/suicide attempts and visual HEs, notable reductions (≥ 10%) in the log OR were evident for depression (40.8–42.0%), psychological distress (28.3–30.9%), mental health service use (20.4–26.7%), being bullied (13.8–17.0%), and insufficient sleep (12.3–15.8%). However, no single variable explained the entire relationship, and the visual HE–self-harm association only became non-significant when depression, psychological distress, and service use were all entered simultaneously into the model (similarly for the visual HE–suicide attempt association when all five variables were entered). This was not the case for DEs. Apart from the association between self-harm and spied-upon, all DE–NASI associations became non-significant when depression diagnosis was entered individually into the model, resulting in a 50.2–101.3% reduction in the log OR. Psychological distress (32.1–64.5% reduction) and low self-esteem (32.6–58.2% reduction), when entered individually, also resulted in a non-significant association between NASI and each DE (thoughts read, special messages, and spied-upon). The spied-upon–suicide attempt association was the exception, where psychological distress but not self-esteem resulted in a non-significant association.

As seen for auditory HEs, the effects of sociodemographics and parental mental illness were negligible in visual HE models and in all DE models (see Online Resource 4). The effects of disordered eating behaviour and social isolation were also negligible in nearly all models, except for thoughts being read and the special messages–self-harm association. All models (except for special messages) showed that substance use and/or low self-esteem resulted in a greater than 10% reduction in the log OR for suicide attempts, but not for self-harm.

Discussion

This study is the first to report on the association between PEs and NASI in a nationally representative sample of Australian adolescents. Except for special messages, each PE subtype (auditory and visual HEs, thoughts read, and spied-upon) was associated with NASI before and after adjustment for confounders (sociodemographics, substance use, and parental mental illness). These results are consistent with Nishida et al.'s [20] findings among Japanese adolescents, where feeling spied-upon and auditory HEs were associated with deliberate self-harm, whereas special messages were not after adjustment for key third variables.

Table 2 Association between auditory hallucinatory experiences and non-accidental self-injury, assessing the influence of third variables (confounders, mediators) individually

Independent variable	Third variables	12-month self-harm, $n = 1849$			12-month suicide attempt, $n = 1887$		
		OR[a]	95% CI	% reduction[b]	OR[a]	95% CI	% reduction[b]
12-month auditory hallucinatory experiences	None (base model)	4.87	[3.47–6.84]	–	6.12	[3.57–10.50]	–
	Potentially confounding variables						
	Base model + sociodemographics						
	Age, sex	4.77	[3.38–6.73]	1.3	5.97	[3.44–10.34]	1.4
	Base model + substance use						
	LT cannabis and other substance use	4.40	[3.07–6.32]	6.4	4.86	[2.76–8.54]	**12.7**
	Base model + family history factors						
	Parental mental illness	4.85	[3.44–6.83]	0.3	5.99	[3.47–10.34]	1.2
	Potentially mediating variables						
	Base model + mental disorders/problems						
	Major depressive disorder	3.21	[2.09–4.95]	**26.3**	2.98	[1.60–5.54]	**39.7**
	Disordered eating behaviour[c]	4.87	[3.47–6.85]	0.0	5.84	[3.38–10.08]	2.6
	Base model + environmental factors						
	Bullied in past 12 months	4.03	[2.82–5.76]	**12.0**	4.82	[2.63–8.85]	**13.2**
	Base model + psychological factors						
	Psychological distress (K10 cutoff)[d]	3.76	[2.45–5.77]	**16.3**	3.56	[1.91–6.62]	**29.9**
	Low self-esteem (ASQ cutoff)[e]	4.88	[3.25–7.32]	+0.1	4.99	[2.80–8.91]	**11.3**
	Base model + intervention factors						
	12-month mental health service use	3.61	[2.47–5.28]	**18.9**	3.72	[2.01–6.88]	**27.5**
	Base model + insufficient sleep [< 8 h per night]	4.12	[2.89–5.90]	**10.6**	5.08	[2.83–9.12]	**10.3**
	Base model + social isolation [composite score 0–5]	4.82	[3.41–6.81]	0.7	5.80	[3.39–9.92]	3.0

Bold indicates that the confounding or mediating factor meets the 10% cut-off point

OR, odds ratio; 95% CI, 95% confidence interval; LT, lifetime; K10, Kessler Psychological Distress Scale; ASQ, Adolescent Self-Esteem Questionnaire

[a]Odds ratio comparing the groups with and without auditory hallucinatory experiences. For all logistic regressions, the reference group is no endorsement of auditory hallucinatory experiences

[b]Percentage change in the point estimate was computed according to the following formula: $\Delta = \frac{\ln \mathrm{OR}_{\text{base model}} - \ln \mathrm{OR}_{\text{base model + third variable}}}{\ln \mathrm{OR}_{\text{base model}}} \times 100$

[c]Binge eating and purging problem eating behaviour group or low weight problem eating behaviour group (groups devised by YMM survey team)

[d]Psychological distress = equal to or above K10 clinical cut-off score of 19

[e]Low self-esteem = equal to or below ASQ cutoff of 17

Simultaneously adjusting for multiple third variables informs the strength of the PE–NASI association independent of confounders, but does not explain the magnitude of contribution of each third variable to the association. Because of this, we examined the individual contribution of confounders and potentially mediating variables to the association. Major depressive disorder was the strongest mediator in all PE–NASI associations, followed by psychological distress, mental health service use, and bullying. For all DEs (special messages, thoughts read, and spied-upon), associations with NASI became non-significant when depression was entered into the model. This would suggest that depression fully mediates the DE–NASI association. The same applies to psychological distress and low self-esteem, both of which resulted in non-significant DE–NASI associations when individually entered into the model. Considering the size of the correlations between each of these third variables (ϕ range = 0.38–0.49; see Online Resource 2), it is likely that depression, self-esteem, and psychological distress all load onto the same broader, mediating construct.

For auditory and visual HEs, no single variable explained the associations, as shown in the change-in-point-estimate analysis in Table 2 and supplementary Online Resource 4. For visual HEs, the associations became non-significant when depression, psychological distress, and service use were all entered simultaneously into the model, which may

be similar to the situation above, where all these variables are potentially loading onto the same broader mediating variable. For auditory HEs, depression and psychological distress resulted in substantial attenuation of the size of associations. Nonetheless, no single variable explained the association, and in fact, the association remained significant after adjustment and consideration for all confounders and mediators in both the self-harm and attempted suicide model. Of all the PEs, auditory HEs appear to be the only PE independently associated with self-injurious and suicidal behaviours. These results are somewhat consistent with an Australian study of university students [14], which found that perceptual abnormalities but not bizarre experiences were associated with suicide attempts. Longitudinal data are required to further inform the nature of these associations, such as whether depression and psychological distress act as mediators or moderators in the auditory HE–NASI association.

Two novel, potentially mediating factors were explored: social isolation and hours of sleep. Sleeping less than 8 h per night contributed greater than 10% reduction in the log OR for both the auditory HE–self-harm and –suicide attempt associations, as well as all other self-harm and suicide attempt associations. Social isolation scores, however, contributed negligible effects in nearly all but one model; the special messages–self-harm association. It is inherently difficult to measure social isolation in a single question, and therefore, studies have attempted to capture this construct by compiling multiple indicators of the quality and frequency of contact with friends/family [37, 41]. Despite following this approach, our social isolation measure may not have been robust enough, and therefore, current findings should be replicated with more standardised measures, such as the Social Inclusion Scale [42].

Despite overlap between the different types of NASI (non-suicidal self-injury and suicide attempts), essential qualitative and phenomenological differences do distinguish suicidal from non-suicidal self-injurious behaviour in adolescents [43]. This was demonstrated in the current findings, where there was overall consistency between the two models but with some key differences, where, for example, substance use and low self-esteem resulted in a greater than 10% reduction in the log OR for the auditory HE–suicide attempt association, but not for the auditory HE–non-suicidal self-injury association. Considering this, future research should attempt to further explore the nuances of the relationship between PEs, non-suicidal, and suicidal NASI. In addition, it will be important for future studies to further develop our understanding of the relationship between PEs and the different levels of suicide risk or severity. Previous studies have shown a dose–response relationship between PEs and suicide risk in adolescent and young adult populations [10, 11].

Strength and limitations

One of the main strengths of this study was the representative data, with schizophrenia and diagnoses of other psychotic disorders sequenced out of the item set so as to prevent overinflation of the PE–NASI association. To our knowledge, this is the first study to apply Firth's bias correction method to the PE–NASI association, a statistical method which aims to present a more accurate prediction of rare events [39]. All significant suicide attempt associations in Table 1 persisted after Firth's bias adjustment, further strengthening the robustness of the relationship between PEs and NASI. Finally, our approach to adjustment and consideration for third variables (confounders, mediators) was comprehensive and novel, incorporating key factors of PEs and NASI (social isolation, insufficient sleep) that had not been previously considered.

This study was limited by the cross-sectional and self-report nature of the data. The number of participants who declined to answer questions about self-harm and suicide attempts also limited the current study. Participants were given the option of not answering these questions and it is probable those who declined to answer were more likely to engage in NASI, although a sensitivity analysis showed that those who responded 'Prefer not say' had a lower prevalence of major depression compared to those who responded 'Yes'.

The overall YMM response rate was 55% with 6,310 parents and carers of eligible households participating in the survey. The relatively low response occurred despite multiple strategies to maximise recruitment, for example, introductory letters to households, up to six call backs at different times of day and on weekends, and financial compensation to parents and young people for their participation. There has been a world-wide decline in response rates for mental health surveys. While analyses of the characteristics of responders relative to the Australian population suggest that the YMM sample is broadly representative, there may be differences and biases that remain uncorrected or unknown which affect the generalisability of findings. The percentage reductions in log ORs should be interpreted only as an indicator of the mediational effect of each variable. With this technique, there is collinearity between the other variables and confounders are not controlled for which may lead to an overinflation of the percentage reductions. However, the results have face validity, for example, showing depression diagnosis has the largest contribution to the relationship between PEs and NASI.

The weaknesses of the PE screening methodology also need to be recognised. PEs are typically defined as occurring outside the context of sleep or substance use [44, 45]; however, in the current survey structure (as in many other epidemiological studies), we were only able to separate out experiences occurring under the influence of alcohol

or drugs, but not PEs occurring in the context of falling or waking from sleep, or sleep problems/disturbances. This has implications for the notable contribution of insufficient sleep to PE–NASI associations, which may have been less influential if sleep-related PEs were taken into account. In addition to the limitations of the PE screening methodology, questions pertaining to the stress associated with PEs themselves were not asked in the YMM survey. Previous studies have found that PE-related stress is particularly relevant to PEs' association with self-injury [10, 15], although part of its variance would likely overlap with psychological distress more broadly. Finally, the YMM survey did not collect data on a history of childhood trauma, which has been associated with both NASI and PEs [46, 47], or Borderline Personality Disorder (BPD) diagnosis or traits, which has been identified as a key third variable in the PE–non-suicidal self-injury association [48]. Kelleher et al. [49] found that BPD did not impact on the PE–suicide attempt association, and therefore, its inclusion would not have likely influenced the association reported in the current study. Nor did the YMM survey measure youth assessed diagnoses of anxiety as measured by the DISC-IV. Future research should examine the independent role these diagnoses have in the PE–NASI association.

Future research and clinical implications

We took an exploratory approach to investigating the individual contribution of third variables. Future research is required to test longitudinal pathways and to help further distinguish between confounders, mediators, and moderators using structural equation modelling with longitudinal data. This statistical approach would allow for inclusion of a time variable, as well as account for the interrelationships between third variables of interest [50, 51]. While the current results are robust, the YMM survey did not directly ask adolescents why they self-harmed. Future research should entail interviews with adolescents to ascertain qualitative information as to why those with PEs, particularly auditory HEs, are more likely to engage in NASI. Evidence of self-injury or suicide attempts occurring as a result of command hallucinations [52] would suggest a causal pathway between the two phenomena. Finally, it will be important for future research to delineate any aspects of the PE–NASI association which are unique to young people. Adolescents may be more vulnerable than adults to being influenced by PEs, due to greater emotional instability, stress sensitivity, and lower sense of identity [53]. These potential age-group differences are important to delineate, as such information could be incorporated into selecting more age appropriate treatment options for NASI among those with PEs.

Whatever the nature of the association between psychotic-like experiences and NASI, those with auditory HEs are at higher risk of self-injury, and clinicians should consider routinely screening young people seeking mental health care for hallucinations [15].

Conclusion

The current study examined the cross-sectional associations between PEs and NASI in a nationally representative sample of Australian adolescents. Only auditory HEs remained associated with both self-harm and attempted suicide after adjustment and consideration for the influence of such variables as major depression, bullying, psychological distress, and substance use. Depression and psychological distress had a substantial impact on all PE–NASI associations, where both appeared to fully explain the DE–NASI association, and partially attenuate the HE–NASI association. Further work is required using structural equation modelling with longitudinal data.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical clearance The research protocol for the study was approved by the Australian Government Department of Health Human Research Ethics Committee, and The University of Western Australia Human Research Ethics Committee. Therefore, the study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. With permission from their parent or carer, the young person aged 14–17 years was given a copy of the Youth Information Brochure, reassured that their responses would be confidential and asked if they would like to participate. Consenting youth were given the use of a CASI tablet computer and, wherever possible, completed the questionnaire in private at the same time that the parent or carer was being interviewed in person.

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