Title: Can't get you out of my head: Persistence and remission of psychotic experiences in adolescents and its association with self-injury and suicide attempts

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ABSTRACT

Background: Persistent psychotic experiences (PEs) may increase risk for mental disorders, non-suicidal self-injury (NSSI), and suicide attempts, relative to PEs that are more transient and remitting in nature. Most investigations of PE persistence have incorporated only two waves of data, and have not investigated the persistence of different PE subtypes and their association with future NSSI and suicide attempts. This study aimed to investigate the association between PE persistence, NSSI, and suicide attempts using three waves of prospective data. A secondary aim was to investigate potential reverse pathways where self-injurious behaviour (and its persistence) instead precedes subsequent PE occurrence.

Method: Participants were 1100 adolescents (12–17 years) from an Australian prospective cohort study; with three time points over two years. The Self-Harm Behaviour Questionnaire was used to assess NSSI and suicide attempts. Four PE subtypes (auditory hallucinatory experiences [HEs], and three delusional experiences) were assessed using the Diagnostic Interview Schedule for Children. Logistic regression analyses were conducted where PEs was grouped into five categories according to their persistence across the three waves of data. Analyses were adjusted for sociodemographics and substance use.

Results: Overall, persistence of PEs (with endorsement of PE across two or three waves) was associated with the highest risk of incident NSSI and suicide attempts at 1- and 2-year follow-up (OR range: 2.57–12.25), whereas remitted PEs (with endorsement of PE at baseline only) were not associated with increased risk of future NSSI or suicide attempts. This pattern of association was evident for auditory HEs but not for most other PE subtypes; although some estimates had wide confidence intervals. There was no support for reverse temporality.

Conclusion: Our findings support and extend the two-wave cohort literature demonstrating that PEs which persist over time are more robust predictors of future NSSI and suicidal behaviour. Auditory HEs that are persisting in nature are an important but under-recognised

risk factor for NSSI and suicide attempts during adolescence, and current findings should inform clinical guidelines into the predictors of self-harm and suicide risk at this life stage.

Key words: hallucinations, delusions, self-harm, NSSI, non-suicidal self-injury, suicide attempt.

1 INTRODUCTION

Most studies examine psychotic experiences (PEs) in terms of their presence versus absence, however, there is growing evidence that PEs that are more persistent in nature are stronger predictors for future psychotic disorders (Poulton et al., 2000; Dominguez et al., 2011), other mental disorders (De Loore et al., 2011), non-suicidal self-injury (NSSI; self-harm without suicidal intent), and suicide attempts (Bromet et al., 2017; Connell et al., 2016; Kelleher, 2014; Martin et al., 2015; Rimvall et al., 2019). Using an Australian birth cohort study, Connell and colleagues (2016) found Australian adolescents reporting hallucinations at both 14 and 21 years were at increased risk of suicidal behaviour (OR range: 2.89–7.11) and psychopathology at 30 years, whereas no association was found in those reporting hallucinations at 14 years only. Similarly in a cohort of Australian high school students (Martin et al., 2015) persistent PEs (present at both baseline and one-year follow-up) were associated with NSSI (OR= 3.20, 95%CI: 1.48–6.91) and suicide attempts (OR= 4.63, 95%CI: 1.21–17.72) but NSSI/suicidality was not associated with PEs reported at baseline only. PE persistence may be an important predictor for the onset and maintenance of self-injurious behaviour, including NSSI and suicide attempts (Hielscher et al., 2018a), among adolescents.

These Australian findings are consistent with international studies. Rimvall et al. (2019) recently investigated persistent PEs from preadolescence (age 11) to adolescence (age 16) with respect to self-injurious behaviour in a Danish birth cohort. Persistent PEs and incident PEs at age 16 were associated with NSSI and suicide attempts at age 16, whereas remitting PEs from age 11 to 16 were not. After adjustment for co-occurring depressive symptoms and general psychopathology, all associations were markedly reduced. Rimvall et al.'s (2019) and Martin et al.'s (2015) studies, whilst important contributions, investigated persistence of PEs by collapsing all subtypes (i.e. hallucinatory and delusional experiences) into one variable. Other studies have found differential strengths in the PE-self-injurious

behaviour association (Capra et al., 2015; Nishida et al., 2010), with hallucinatory experiences more consistently associated with self-injurious outcomes than other PEs. Also, Rimvall et al.'s (2019) study, like nearly all longitudinal PE-self-injurious behaviour studies, was conducted across two waves of data, which limits the ability to examine PE trajectories across multiple time points (Ployhart and MacKenzie, 2015). Collection of data over an increased number of time points (thereby allowing for more reliable observation of the relationships; Ployhart and MacKenzie, 2015), and examination of the trajectories of different PE subtypes (thereby identifying more clinically relevant subtypes), would extend the existing body of work.

In addition to these considerations, none of the above studies investigated the reverse in terms of self-injurious behaviour, its persisting nature, and potential association with subsequent PE occurrence. While the temporal relationship of PE predicting future self-injurious behaviour seems intuitively more plausible, it has been proposed that PEs, for some, may be consequential to self-injurious thoughts and behaviours (Butter, 2019; Forman et al., 2004; Murphy et al., 2018). This has been explained within the context of threat responsivity, where PEs may be an adaptive response to the severe distress of self-injurious/suicidal experiences (i.e. PEs serve to externalise thoughts or behaviours that, when internalised, would manifest as self-injurious behaviour) (Butter, 2019; DeVylder et al., 2020; Murphy et al., 2018). Preliminary support for this hypothesis was found using cross-sectional data from the UK (i.e. the British Psychiatric Morbidity Survey, and Adult Psychiatric Morbidity Survey), where individuals who thought about and had attempted suicide in their lifetime (and in the year of assessment) were much more likely to report PEs, compared to non-suicidal members of the UK population (Murphy et al., 2018). Further investigation of this hypothesis is required using prospective data from other countries.

To address our study aims, we utilised a prospective cohort study of Australian adolescents in which data on several different PE subtypes, and NSSI and suicide attempts,

were collected (at three time points over two years). Specifically, we aimed to: (1) examine the association between PE persistence and remission with incident self-injurious behaviour, and (2) examine if there is evidence of reverse temporality where self-injurious behaviour (and its persistence) is associated with subsequent occurrence of PEs. These aims, which comprehensively investigate the direction and dynamic nature of the PE-self-injurious behaviour association, are important for furthering our understanding as to why there is a relationship between these two phenomena.

2 METHODS

2.1 Sample

Participants were from the Helping to Enhance Adolescent Living, or HEALing Project, a prospective three-wave cohort study of Australian adolescents (aged 12–17 years). This study, which collected data at three time points (12 months apart), has been previously described in detail (Hielscher et al., 2020a, 2020b; Martin et al., 2015). As outlined by Hielscher and colleagues (2020b), 41 secondary schools participated where, of those with parental consent, 2640 (84.6%) high-school students completed the survey at baseline (T0). Of these, 1975 students (74.8%) completed the survey at 1-year follow-up (T1) and 1263 students (47.8%) completed the survey at all three waves (T0–T2). A final sample of 1100 adolescents was used in analyses (see 'Attrition and missing data' section).

The study was approved by The University of Queensland and Monash University Human Research Ethics Committees. Consent was provided by school principals, parents, and students.

2.2 Attrition and missing data

As reported previously in Hielscher et al. (2020b), adolescents that were lost to follow-up in the HEALing study (LTF; n=1377, either at T1 [n=665] or T2 [n=712]; 52.2% of total sample) were older, male, more likely to report PEs at baseline, and report engaging in NSSI or attempted suicide at baseline.

Twenty-four (of the total 1263) HEALing study participants were excluded because they were older than 17 years of age at one data collection point (T0 and/or T1 and/or T2); as consistent with Hielscher et al.'s (2020b) approach. Listwise deletion was used to handle missing data, where an additional 139 participants were excluded that did not respond to all key items (PE, NSSI, and suicide attempt) at all three time points (T0–T2). For all analyses, a final sample of n=1100 was used. Overall, our results were largely consistent with those obtained by multiple imputation, producing similar parameter estimates for all analyses.

2.3 Key variables

2.3.1 Psychotic experiences

PEs were assessed using items from the Schizophrenia section of The Diagnostic Interview Schedule for Children – revised version (DISC-R; Shaffer et al., 1993). From this, one item asked about lifetime auditory hallucinatory experiences (HEs), and three items captured delusional experiences (DEs) of thoughts being read, feeling spied upon, and receiving special messages. These four self-report items have been previously used to screen for PEs among adolescents (Kelleher et al., 2012; Poulton et al., 2000). The DISC auditory hallucinatory item has high concurrent validity with clinician-rated psychotic symptoms (Kelleher et al., 2011). In the current study, we focused on 'any PE'[1] and 'auditory HEs', given previous adolescent studies (Hielscher et al., 2019, 2020a) have shown auditory HEs as the only PE subtype (when categorised by presence vs. absence) which remains associated with NSSI and suicide attempts, after adjustment (and consideration for) relevant confounding and mediating variables. HEALing study participants were classified as endorsing auditory HEs if they responded 'yes, definitely' to DISC-R item '*heard voices other people cannot hear?*' at baseline (T0). In the current study, auditory HEs did not exclude for the presence of DEs. It is worth noting, however, that less than 20% of

[1] Endorsement of either: auditory hallucinatory experiences or thoughts being read or receiving special messages or feeling spied upon.

participants endorsing HEs at each timepoint also endorsed any DEs (at baseline: 18.7% of participants endorsed HEs and DEs; at T1: 18.3% of participants endorsed HEs and DEs; at T2: 13.7% of participants endorsed HEs and DEs).

Similar to Hielscher et al.'s (2020b) study, incident HEs at one-year follow-up were coded if participants responded 'no' at T0, but 'yes, definitely' at T1. Incident HEs at two-year follow-up were coded if participants responded 'no' at T0 and T1, but 'yes, definitely' at T2. The same coding was applied to all other PE subtypes. No participant reported being diagnosed with schizophrenia or psychosis at any point in the study.

2.3.2 NSSI and suicide attempts

The Self-Harm Behaviour Questionnaire (Gutierrez et al., 2001) was used to measure NSSI and suicide attempts. NSSI (or self-harm without suicidal intent) was assessed using the item '*have you ever hurt yourself on purpose?'* (yes or no); preceded by a definition 'hurting yourself on purpose without trying to die'[2]. Also consistent with Hielscher et al.'s (2020b) study, incident NSSI one year later was coded if participants responded 'no' at T0 but 'yes' at T1. Incident NSSI two years later was coded if participants responded 'no' at T0 and T1, but 'yes' at T2. Suicide attempts, which were assessed using the item '*Did you ever try to end your life?*' (yes or no), were coded the same way as NSSI variables. There were no deaths by suicide in the sample.

2.4 Confounders

Age (in years) and sex of cohort participants were included as potential confounders. Lifetime cannabis/other illicit substance use was also included as a possible confounder in all analyses. We were not able to separate out PEs occurring under the influence of alcohol or other drugs (DeVylder and Kelleher, 2016; Hielscher et al., 2018a).

[2] This item was further revised to include only direct self-injury methods (e.g. cutting, hitting), as based on participant qualitative data (Hielscher et al., 2020b).

2.5 Statistical analysis

All analyses were conducted using Stata/IC 14. NSSI and suicide attempts were modelled separately in this study.

To address **Aim 1** (i.e. association of PE persistence with self-injurious behaviour), we conducted a logistic regression analysis where PEs were grouped according to their persistence across the three waves of data, as based on previous analyses by Martin et al. (2015) and Rimvall et al. (2019): (i) never PE (i.e. PEs absent[3] across all three waves; *reference group*), (ii) remitted PE (i.e. PEs present at baseline only), (iii) incident PE (i.e. PEs absent at baseline, but present at T1 only or T2 only), (iv) persistent PE – two waves (PEs present at baseline and T1, but absent at T2; or PEs absent at baseline, but present at T1 and T2), and (v) persistent PE – three waves (PEs present across all follow-ups). See Figure 1 for details on each of the five groupings. Using logistic regression, we then examined associations between the five groups and incident self-injurious behaviour (incident self-injurious behaviour is defined on pg.8).

To address **Aim 2** (i.e. potential reverse temporal pathways), logistic regressions were used to examine the relationship between self-injurious behaviour at baseline (i.e. baseline NSSI or suicide attempts) and occurrence of incident PEs at T1 and T2 (incident PE is defined on pg.8); as well as the relationship between T1 self-injurious behaviour and incident PEs at T2. In addition, we also investigated the persistence of self-injurious behaviour and its association with subsequent PE occurrence. Similar to PE persistence models, we conducted a logistic regression analysis where self-injurious behaviour was grouped into the following five groups: (i) never self-injurious behaviour (i.e. self-injurious behaviour absent across all three waves; *reference group*), (ii) remitted self-injurious behaviour (i.e. self-injurious behaviour present at baseline only), (iii) incident self-injurious behaviour (i.e. self-injurious

[3] PEs were considered 'absent' if participants responded either 'no' or 'yes, likely' at a relevant time point. Only those who responded 'yes, definitely' to DISC items were classified as endorsing "true" PEs.

behaviour absent at baseline, but present at T1 only or T2 only), (iv) persistent self-injurious behaviour – two waves (self-injurious behaviour present at baseline and T1, but absent at T2; or self-injurious behaviour absent at baseline, but present at T1 and T2), and (v) persistent self-injurious behaviour – three waves (self-injurious behaviour present at all three waves). Persistence was modelled separately for NSSI and suicide attempts.

3 RESULTS

There were 1100 participants who participated in all data collection phases. Their mean age was 13.8 (SE=.03) at baseline, and 75.9% were female.

3.1 Aim 1: PE persistence and incident NSSI/suicide attempt associations

Figure 1 shows the trajectories of PEs across the three waves, with 68.1% of participants never reporting PEs, 6.0% reporting persistent PEs across two waves, and 3.8% reporting PEs across all three waves of data (see Supplementary Material 1 for a baseline clinical profile of those reporting persistent PE trajectories). A similar persistence pattern was found for auditory HEs; with 89.6% of participants never reporting HEs, and 3.0% reporting persistent HEs across two or three waves (see Supplementary Material 2). PE persistence rates were consistent with previous studies (De Loore et al., 2011; DeVylder et al., 2015; Rimvall et al., 2019).

[Insert Figure 1 about here]

As seen in Table 1, overall, persistence of any PE (with endorsement of PE across two or three waves) was associated with the increased risk of incident NSSI and suicide attempts at T1 and T2 (OR range: 2.57–12.25), whereas remitted PEs (with endorsement of PE at baseline only) was not associated with increased risk of NSSI or suicide attempts at either time point (OR range: 0.40–2.40). A similar pattern was found for auditory HEs (see Table 2), where persistence of HEs (across either two or three waves) was associated with the highest risk of NSSI or suicide attempts (OR range: 5.21–48.18), whereas there was no association between remitted HEs and NSSI or suicide attempts; except for incident suicide

attempts at T1, which was associated with remitted HEs (see Table 2). Incident PEs (where PEs absent at baseline, but present at T1 or T2 only) was also associated with incident NSSI and suicide attempts, but only with self-injurious behaviour at T2 (not T1), and with somewhat smaller effect sizes than persistence categories (Tables 1–2). Linear trend in odds ratios (never>remitted>
incident>persistent1>persistent2), as assessed using linear-by-linear associations, was significant (p<.05) for all 'any PE' and 'auditory HE' models; except for auditory HE–incident T1 NSSI ($\chi^2(1)=1.56$, p=.21).

The persistence findings of other PE subtypes (data not shown) were largely not consistent with auditory HEs results. All 'thoughts read' and 'special message' models at T1 and T2 did not demonstrate a significant linear trend in odds ratio; except for the thoughts read–incident NSSI (at T2) ($\chi^2(1)=9.14$, p=.002). For 'feeling spied upon', the linear trend in odds ratios was significant for all NSSI and suicide attempt models at both time points.

[Insert Tables 1–2 about here]

3.2 Aim 2: Potential reverse temporality (i.e. NSSI/suicide attempt and incident PE associations)

Of the total sample, 93 (8.5%; 95%CI = 6.8–10.1) participants reported engaging in NSSI at baseline, and 12 (1.1%; 95%CI = 0.5–1.7) reported attempting suicide at baseline (see Hielscher et al., 2020b for detailed descriptive statistics of the baseline sample). As seen in Table 3, baseline NSSI and suicide attempts were not associated with incident PE at T1 or T2. Similarly, baseline suicide attempts were not associated with incident HEs at either time point. Baseline NSSI was associated with incident HEs at T1 (OR = 4.75; 95%CI = 2.03–11.14) but not at T2, and T1 NSSI was associated with incident HEs at T2 (OR = 3.78; 95%CI = 1.29–11.09) (see Table 3).

[Insert Table 3 about here]

Figure 2 shows the trajectories of NSSI and suicide attempts across the three waves, with 80.0% (95%CI = 77.6–82.4) of participants never reporting NSSI, 4.5% (95%CI = 3.2–5.6) reporting persistent NSSI across two waves, and 5.5% (95%CI = 4.2–6.9) reporting NSSI at all three time points. For suicide attempts, 96.4% (95%CI = 95.3–97.4) of participants reported never attempting suicide, 0.6% (95%CI = 0.2–1.2) reported persistent suicide attempts across two waves, and 0.5% (95%CI = 0.2–1.0) reported attempting suicide at all three waves of data.

As seen in Table 4, overall, increasing persistence of self-injurious behaviour was not associated with increased risk of incident PE at T1 or T2; except for persistence of NSSI (across two waves) and incident PEs at T1 (OR = 2.50; 95%CI = 1.07–5.86). Similarly, increasing persistence of NSSI and suicide attempts was not associated with increased risk of subsequent auditory HEs (see Table 4); except for persistent NSSI (across three waves) and incident HEs at T1 (OR = 8.95; 95%CI = 3.44–23.28), and persistent NSSI (across two waves) and incident HEs at T2 (OR = 7.41; 95%CI = 1.89–28.96). Linear trend in odds ratios (never>remitted>incident>persistent1>persistent2), as assessed using linear-by-linear associations, was non-significant for all NSSI and suicide attempt models in Table 4, except for NSSI – incident PEs/HEs at T1 ($\chi^2(1)=5.85$, $p=.02$; $\chi^2(1)=15.59$, $p<.001$). It should be noted that for suicide attempt models (Tables 3–4), cell counts were low or zero for some persistence categories, and some estimates had wide confidence intervals.

[Insert Figure 2 and Table 4 about here]

4 DISCUSSION

Our aim was to investigate persistence of PEs and its association with NSSI and suicide attempts using three waves of prospective data. We found that, overall, persistence of PEs (with endorsement of PE across two or three waves) was associated with the highest risk of incident NSSI and suicide attempts, whereas remitted PEs (with endorsement of PE at baseline only) were not associated with increased risk, at either time point. Incident PEs were

also fairly consistently associated with incident NSSI and suicide attempts, but only with self-injurious behaviour at T2. This pattern of findings was evident for both 'any PE' and 'auditory HEs', and linear trends in odds ratios (from *'remitted'* to *'persistent – three waves'* categories) were significant for nearly all models (see Tables 1–2). Our results are consistent with Martin et al.'s (2015) and Connell et al.'s (2016) two-wave persistence findings in Australian adolescents, as well as somewhat consistent Rimvall et al.'s (2019) Danish findings, which found incident and persistent PE trajectories (from preadolescence to adolescence) were mostly associated with subsequent NSSI and suicide attempts, whereas remitting PEs were not. In contrast to the current study, after adjusting for general psychopathology and depression, Rimvall et al. (2019) found the effects of PE persistence variables were reduced, becoming non-significant within NSSI but not suicide attempt models. Our study was not powered enough for extensive statistical adjustments; this would require further investigation in future larger (three-wave) studies. Overall, our findings support and extend the previous (two wave cohort) literature demonstrating that PEs which persist over time are more robust predictors of future NSSI and suicidal behaviour.

We also investigated whether there was any evidence of reverse temporality, i.e. where self-injurious behaviour is associated with subsequent occurrence of PEs. This was one of the first prospective studies to investigate the reverse pathway hypothesis with respect to the PE-self injurious behaviour association; however, we did not find strong support for this hypothesis. Baseline NSSI and suicide attempts were not associated with incident PEs at T1 or T2. Similarly, baseline suicide attempts were not associated with incident HEs at either time point (*no cases reported),* where significant associations were only found between baseline NSSI and incident HEs at T1, and T1 NSSI and incident HEs at T2, with relatively large point estimates. In terms of persistence findings, persistence of self-injurious behaviour was generally not associated with increased risk of incident PEs or HEs at either time point, and linear trends in odds ratios were non-significant for nearly all persistence models (except

for NSSI – incident T1 PEs/HEs). Our findings are at odds with Murphy et al.'s (2018) results, which found preliminary support for this hypothesis using two cross-sectional surveys. The assessment periods of both phenomena overlapped in Murphy et al.'s (2018) study, and therefore temporal ordering could not be established; this is necessary when investigating potential reverse pathways (Lawlor et al., 2006). Establishing whether there is an effect in the reverse direction is a useful preliminary test of a proposed reverse causal relationship (Kamangar, 2012). Such a pathway appears to not explain why there is an association between PEs and self-injurious behaviour, as consistent with clinical assumptions about these two phenomena (Hielscher et al., 2018a).

4.1 Strengths and limitations

4.1.1 Strengths

A key strength of the current study was its longitudinal design allowing for clear establishment of the temporal ordering of PEs and self-injurious behaviour, and exclusion of baseline NSSI/suicide attempts. This is not often achieved in the PE-self-injurious behaviour literature (Hielscher et al., 2018a; Rimvall et al., 2019). Having three waves of data was a particular strength, allowing us to investigate in detail the trajectories of these dynamic phenomena. We were also able to investigate the trajectories of different types of PEs, which has not been done previously. Current findings support the growing evidence for the specific and important role of hallucinatory experiences in NSSI and suicide attempts (Capra et al., 2015; DeVylder et al., 2015; Hielscher et al., 2020a, 2020b; Thompson et al., 2020), and that refining analyses to the level of individual symptoms is important (De Loore et al., 2011) and informative for understanding those who may carry greater clinical need (DeVylder et al., 2015; Martin et al., 2015).

In the broader self-harm/suicide literature, few longitudinal investigations have examined suicide attempts over multiple time points (Barrocas et al., 2015; Erausquin et al., 2019; Law and Shek, 2016; Prinstein et al., 2008) which is critical for better understanding

the characteristics of this high-risk group (Czyz and King, 2015). Over 95% of the current sample reported never engaging in suicidal behaviour, with less than 1% persistently engaged in suicide attempts across all three waves. Finally, the current study was able to investigate reverse temporal pathways, which has been largely ignored but is important to investigate in order to rule out alternative reasons as to why there is an association between PEs and self-injurious behaviour.

4.1.2 Limitations

Generalisability is limited as the HEALing sample was drawn from non-government, catholic and independent schools, which are generally attended by adolescents from families with parents who likely have higher levels of education and socioeconomic status (Hielscher et al., 2020a). Religious affiliation may also be protective against suicide (Hielscher et al., 2020a). Our study experienced attrition where those who were older, male, reported PEs, and NSSI/suicide attempts at baseline were more likely to be lost to follow-up. The sample size, whilst large (n=1100), was still underpowered for investigating low prevalence outcomes (suicide attempts); potentially resulting in type II errors (i.e. where true associations are reported as non-significant) (Hielscher et al., 2020b). Many estimates had wide confidence intervals, and for auditory HEs (Table 2) and suicide attempt models (Tables 3–4) in particular, cell sizes were small or even zero. We recommend caution when interpreting these results. Confidence intervals were also overlapping for most PE persistence categories; however, linear trends in odd ratios were statistically demonstrated.

The PE persistence variable, which was informed by Rimvall et al.'s (2019) categorisation, was constructed using DISC-R lifetime variables (e.g. *'have you ever heard voices other people cannot hear?'*). Some participants may have endorsed this item at all three time points based on a single hallucinatory experience which occurred prior to baseline. Considering only 3.8% of participants reported PEs at all three waves (with 19.9% reporting PEs at baseline, see Figure 1), this seems unlikely. Instead, it appears participants were

reporting in a way that was reflective of recent experiences; as also reported in De Loore et al.'s (2011) PE persistence study using DISC-C lifetime items. The study was not sufficiently powered for extensive statistical adjustments, nor was it designed to explore potential underpinning mechanisms of PE persistence (and its links to incident suicidal behaviour). The study also did not take into consideration the stress associated with PEs themselves (which are particularly relevant to PEs' association with self-injurious behaviour; (Martin et al., 2015, DeVylder et al., 2015). Finally, all key study variables were single, self-reported survey items and, therefore, are prone to recall and measurement bias.

4.2 Clinical implications

PE is a broad and heterogeneous construct where many epidemiological surveys do not distinguish between a single fleeting experience and recurrent or persistent distortions of reality (DeVylder et al., 2015; Hielscher et al., 2018b; Maijer et al., 2019). The current findings highlight the clinical importance of a more in-depth understanding of the phenomenological qualities of PEs to inform self-harm/suicide risk. We showed PE persistence, as well as the type of persisting experience, are key considerations for understanding and predicting NSSI and suicidal behaviour among young people. Those reporting persisting auditory HEs are at high risk and clinicians should be incorporating questions of persistent auditory HEs into youth screening tools for self-harm/suicide; whereas remitting patterns (which was almost half of those reporting PEs at baseline) should not in themselves cause concern for increased risk for NSSI and suicidal behaviour (Rimvall et al., 2019). Clinicians are encouraged to initially adopt a "curious-but-cautious" attitude, seeking to learn more about a young person's hallucinatory experience and its broader context[32]. All other PE subtypes in this study (except for feeling spied upon) did not demonstrate similar persistence patterns with respect to self-injurious and suicidal risk, although there were wide confidence intervals around some of these estimates.

4.3 Future research

The current study's data collection was conducted annually, which may not have been ideal for capturing the dynamic components of PEs and self-injurious behaviour. Therefore, future longitudinal studies should consider collecting more measurements, closer in time (e.g. using Ecological Momentary Assessment study designs); both within and across different life stages. It would also be worthwhile incorporating different modelling approaches, such as latent growth modelling, which estimates growth over time (Curran et al., 2010). Such analyses, however, require large sample sizes and repeated measures that are typically continuous (Curran et al., 2010).

Our study did not find support for reverse temporality and thus reverse causality is unlikely. However, considering the study's limitation, it cannot be entirely ruled out. Simultaneity (Mishra et al., 2017), where phenomena both cause each other (PEs→ self-injurious behaviour *and* self-injurious behaviour→ PEs) is plausible (McGrath et al., 2016; Plana-Ripoll et al., 2019) but requires particular modelling approaches with a strict set of assumptions (e.g. using cross-lagged regression models) (Berry and Willoughby, 2017; Hamaker et al., 2015; Hernandez and Johnston, 2016). Finally, investigations into factors which distinguish between those who 'persist' versus 'cease' to engage in NSSI and suicidal behaviour was outside the scope of the current study but would be very informative for guiding prevention and early intervention work with young people.

4.4 Conclusions

This cohort study found evidence supporting the degree of persistence of PEs was associated with a linear increase in risk for subsequent NSSI and suicide attempts, across three waves of prospective data. Auditory HEs that are persisting in nature (over several years) is an important, but under-recognised, risk factor for NSSI and suicide attempts during adolescence, and current findings should help inform clinical guidelines into the management of self-harm and suicide risk at this life stage.

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Declaration of competing interest

The authors declare no conflicts of interest.

Figure legends

Figure 1. Trajectories of psychotic experiences (PEs) across the three waves of data (n=1100)

Figure 2. Trajectories of **(A)** non-suicidal self-injury (NSSI) and **(B)** suicide attempts across the three waves of data (n=1100)

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Table 1. Association between persistence of psychotic experiences (PE) and incident NSSI/suicide attempts (at T1 and T2), unadjusted and adjusted for confounders (n=1100)

	Incident NSSI at 1-year follow-up								Incident NSSI at 2-year follow-up							
	Yes (n=61)		No (n=1039)		Unadjusted		Model 1[a]		Yes (n=66)		No (n=1034)		Unadjusted		Model 1[a]	
	n	%	n	%	OR	95%CI	OR	95%CI	n	%	n	%	OR	95%CI	OR	95%CI
Never PE	32	4.3	717	95.7	*Ref*	-	*Ref*	-	35	4.7	714	95.3	*Ref*	-	*Ref*	-
Remitted PE	7	6.4	102	93.6	1.54	0.66–3.58	1.60	0.68–3.72	2	1.8	107	98.2	0.38	0.09–1.61	0.40	0.09–1.68
Incident PE	10	7.5	124	92.5	1.81	0.87–3.77	1.88	0.90–3.95	16	11.9	118	88.1	**2.77**	**1.48–5.16**	**2.88**	**1.53–5.40**
Persistent PE (1)	7	10.6	59	89.4	**2.66**	**1.13–6.28**	**2.82**	**1.19–6.70**	7	10.6	59	89.4	**2.42**	**1.03–5.68**	**2.57**	**1.09–6.06**
Persistent PE (2)	5	11.9	37	88.1	**3.03**	**1.12–8.22**	2.56	0.85–7.72	6	14.3	36	85.7	**3.40**	**1.34–8.60**	**2.80**	**1.03–7.66**
	Incident suicide attempts at 1-year follow-up								**Incident suicide attempts at 2-year follow-up**							
	Yes (n=9)		No (n=1091)		Unadjusted		Model 1[a]		Yes (n=19)		No (n=1081)		Unadjusted		Model 1[a]	
	n	%	n	%	OR	95%CI	OR	95%CI	n	%	n	%	OR	95%CI	OR	95%CI
Never PE	3	0.4	746	99.6	*Ref*	-	*Ref*	-	7	0.9	742	99.1	*Ref*	-	*Ref*	-
Remitted PE	1	0.9	108	99.1	2.30	0.24–22.33	2.40	0.25–23.48	1	0.9	108	99.1	0.98	0.12–8.06	1.03	0.13–8.44
Incident PE	1	0.7	133	99.3	1.87	0.19–18.11	1.92	0.20–18.75	6	4.5	128	95.5	**4.97**	**1.64–15.02**	**5.18**	**1.70–15.77**
Persistent PE (1)	2	3.0	64	97.0	**7.77**	**1.28–47.36**	**8.17**	**1.33–50.07**	3	4.5	63	95.5	**5.05**	**1.27–19.20**	**5.38**	**1.35–21.41**
Persistent PE (2)	2	4.8	40	95.2	**12.43**	**2.02–76.53**	**12.25**	**1.95–77.04**	2	4.8	40	95.2	**5.30**	**1.07–26.34**	**5.83**	**1.16–29.38**

Note. Never PE = psychotic experiences absent across all three waves of data; remitted PE = psychotic experiences present at baseline only; incident PE = psychotic experiences absent at baseline, but present at T1 or T2 only; persistent PE – two waves = psychotic experiences present at baseline and T1 but absent at T2, or psychotic experiences absent at baseline but present at T1 and T2; persistent PE – three waves = psychotic experiences present across all three waves; OR = odds ratio; 95%CI = 95% confidence interval; NSSI= non-suicidal self-injury; PE = any psychotic experience i.e., auditory hallucinatory experiences, thoughts read, special messages received or spied-upon.
Bold indicates significant odds ratio ($p < 0.05$). Linear trend in odds ratio (never>remitted>incident>persistent1>persistent2), as assessed using linear-by-linear associations (X^2), were significant for all models.
[a] Model 1: adjusted for sociodemographics (age, sex) and lifetime substance use (cannabis and other illicit substances).

Table 2. Association between persistence of auditory hallucinatory experiences (AHE) and incident NSSI/suicide attempts (at T1 and T2), unadjusted and adjusted for confounders (n=1100)

	Incident NSSI at 1-year follow-up								Incident NSSI at 2-year follow-up							
	Yes (n=61)		No (n=1039)		Unadjusted		Model 1[a]		Yes (n=66)		No (n=1034)		Unadjusted		Model 1[a]	
	n	%	n	%	OR	95%CI	OR	95%CI	n	%	n	%	OR	95%CI	OR	95%CI
Never AHE	53	5.4	933	94.6	*Ref*	-	*Ref*	-	53	5.4	933	94.6	*Ref*	-	*Ref*	-
Remitted AHE	0	0	35	100.0	-	-	-	-	3	8.6	32	91.4	1.65	0.49–5.56	1.86	0.55–6.31
Incident AHE	4	8.7	42	91.3	1.68	0.58–4.85	2.08	0.71–6.12	6	13.0	40	87.0	**2.64**	**1.07–6.50**	**2.53**	**1.01–6.31**
Persistent AHE (1)	4	20.0	16	80.0	**4.40**	**1.42–13.63**	**5.21**	**1.65–16.47**	2	10.0	18	90.0	1.95	0.44–8.64	1.95	0.44–8.68
Persistent AHE (2)	0	0	13	100.0	-	-	-	-	2	15.4	11	84.6	3.20	0.69–14.79	3.60	0.75–17.24
	Incident suicide attempts at 1-year follow-up								**Incident suicide attempts at 2-year follow-up**							
	Yes (n=9)		No (n=1091)		Unadjusted		Model 1[a]		Yes (n=19)		No (n=1081)		Unadjusted		Model 1[a]	
	n	%	n	%	OR	95%CI	OR	95%CI	n	%	n	%	OR	95%CI	OR	95%CI
Never AHE	4	0.4	982	99.6	*Ref*	-	*Ref*	-	12	1.2	974	98.8	*Ref*	-	*Ref*	-
Remitted AHE	2	5.7	33	94.3	**14.88**	**2.63–84.05**	**16.36**	**2.86–93.41**	1	2.9	34	97.1	2.39	0.30–18.87	2.69	0.34–21.41
Incident AHE	1	2.2	45	97.8	5.45	0.60–49.76	4.96	0.52–47.07	3	6.5	43	93.5	**5.66**	**1.54–20.79**	**6.75**	**1.78–25.51**
Persistent AHE (1)	0	0	20	100.0	-	-	-	-	3	15.0	17	85.0	**14.31**	**3.70–55.36**	**16.34**	**4.11–64.89**
Persistent AHE (2)	2	15.4	11	84.6	**44.59**	**7.38–69.33**	**48.18**	**7.60–65.43**	0	0	13	100.0	-	-	-	-

Note. Never AHE = auditory hallucinatory experiences absent across all three waves of data; remitted AHE = auditory hallucinatory experiences present at baseline only; incident AHE = auditory hallucinatory experiences absent at baseline, but present at T1 or T2 only; persistent AHE – two waves = auditory hallucinatory experiences present at baseline and T1 but absent at T2, or auditory hallucinatory experiences absent at baseline but present at T1 and T2; persistent AHE – three waves = auditory hallucinatory experiences present across all three waves; OR = odds ratio; 95%CI = 95% confidence interval; NSSI = non-suicidal self-injury; AHE = auditory hallucinatory experiences.
Bold indicates significant odds ratio ($p < 0.05$). Linear trend in odds ratio (never>remitted>incident>persistent1>persistent2), as assessed using linear-by-linear associations (X^2), were significant for all models except for the auditory HE-incident T1 NSSI model ($X^2(1)=1.56$, $p=.21$).

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

Table 3. Association between baseline NSSI/suicide attempts (SA) and incident psychotic experiences (at T1 and T2), n=1100

Independent variable: NSSI/SA at baseline	**Incident PEs at 1-year follow-up**								**Incident PEs at 2-year follow-up**							
	Yes (n=79)		**No (n=1021)**		**Unadjusted**		**Model 1[a]**		**Yes (n=53)**		**No (n=1047)**		**Unadjusted**		**Model 1[a]**	
	n	**%**	**n**	**%**	**OR**	**95%CI**	**OR**	**95%CI**	**n**	**%**	**n**	**%**	**OR**	**95%CI**	**OR**	**95%CI**
Baseline NSSI (+)	7	7.5	86	92.5	1.06	0.47–2.37	1.25	0.55–2.83	5	5.4	88	94.6	1.14	0.44–2.93	1.42	0.52–3.89
Baseline NSSI (-)	72	7.1	935	92.9	*Ref*	-	*Ref*	-	48	4.8	959	95.2	*Ref*	-	*Ref*	-
Baseline SA (+)	0	0	12	100.0	-	-	-	-	1	8.3	11	91.7	1.81	0.23–14.30	2.46	0.26–23.44
Baseline SA (-)	79	7.3	1009	92.7	*Ref*	-	*Ref*	-	52	4.8	1036	95.2	*Ref*	-	*Ref*	-
Independent variable: NSSI/SA	**Incident auditory HEs at 1-year follow-up**								**Incident auditory HEs at 2-year follow-up**							
	Yes (n=32)		**No (n=1068)**		**Unadjusted**		**Model 1[a]**		**Yes (n=18)**		**No (n=1081)**		**Unadjusted**		**Model 1[a]**	
	n	**%**	**n**	**%**	**OR**	**95%CI**	**OR**	**95%CI**	**n**	**%**	**n**	**%**	**OR**	**95%CI**	**OR**	**95%CI**
Baseline NSSI (+)	8	8.6	85	91.4	**3.86**	**1.68–8.84**	**4.75**	**2.03–11.14**	2	2.2	91	97.8	1.36	0.31–6.01	1.60	0.35–7.20
Baseline NSSI (-)	24	2.4	983	97.6	*Ref*	-	*Ref*	-	16	1.6	990	98.4	*Ref*	-	*Ref*	-
Baseline SA (+)	0	0	12	100.0	-	-	-	-	0	0	12	100.0	-	-	-	-
Baseline SA (-)	32	2.9	1056	97.1	*Ref*	-	*Ref*	-	18	1.7	1069	98.3	*Ref*	-	*Ref*	-
Independent variable: NSSI/SA at T1	**Incident PEs at 2-year follow-up**								**Incident auditory HEs at 2-year follow-up**							
	Yes (n=53)		**No (n=1047)**		**Unadjusted**		**Model 1[a]**		**Yes (n=18)**		**No (n=1081)**		**Unadjusted**		**Model 1[a]**	
	n	**%**	**n**	**%**	**OR**	**95%CI**	**OR**	**95%CI**	**n**	**%**	**n**	**%**	**OR**	**95%CI**	**OR**	**95%CI**
Baseline NSSI (+)	6	4.6	125	95.4	0.94	0.39–2.25	1.11	0.45–2.74	5	3.8	126	96.2	**2.92**	**1.02–8.31**	**3.78**	**1.29–11.09**
Baseline NSSI (-)	47	4.9	922	95.1	*Ref*	-	*Ref*	-	13	1.3	955	98.7	*Ref*	-	*Ref*	-
Baseline SA (+)	1	6.7	14	93.3	1.42	0.18–11.00	1.64	0.20–13.47	0	0	15	100.0	-	-	-	-
Baseline SA (-)	52	4.8	1033	95.2	*Ref*	-	*Ref*	-	31	2.9	1053	97.1	*Ref*	-	*Ref*	-

Note. OR = odds ratio; 95%CI = 95% confidence interval; NSSI = non-suicidal self-injury; SA = suicide attempt; PEs = any psychotic experience, i.e., auditory hallucinatory experiences, thoughts read, special messages received or spied-upon; HEs = auditory hallucinatory experiences. Bold indicates significant odds ratio ($p < 0.05$).

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

Table 4. Association between persistence of NSSI/suicide attempts (SA) and incident PEs (at T1 and T2), n=1100

	Incident PEs at 1-year follow-up								Incident PEs at 2-year follow-up							
	Yes (n=79)		No (n=1021)		Unadjusted		Model 1[a]		Yes (n=53)		No (n=1047)		Unadjusted		Model 1[a]	
	n	%	n	%	OR	95%CI	OR	95%CI	n	%	n	%	OR	95%CI	OR	95%CI
Never NSSI	55	6.3	825	93.8	*Ref*	-	*Ref*	-	38	4.3	842	95.7	*Ref*	-	*Ref*	-
Remitted NSSI	0	0	14	100.0	-	-	-	-	2	14.3	12	85.7	3.69	0.80–17.09	3.63	0.76–17.38
Incident NSSI	11	11.5	85	88.5	1.94	0.98–3.85	1.99	1.00–3.97	8	8.3	88	91.7	2.01	0.91–4.45	**2.27**	**1.01–5.09**
Persistent NSSI(1)	7	14.3	42	85.7	**2.50**	**1.07–5.82**	**2.50**	**1.07–5.86**	2	4.1	47	95.9	0.94	0.22–4.03	1.05	0.24–4.53
Persistent NSSI(2)	6	9.8	55	90.2	1.64	0.68–3.97	2.08	0.84–5.14	3	4.9	58	95.1	1.15	0.34–3.83	1.63	0.46–5.85

	Incident PEs at 1-year follow-up								Incident PEs at 2-year follow-up							
	Yes (n=79)		No (n=1021)		Unadjusted		Model 1[a]		Yes (n=53)		No (n=1047)		Unadjusted		Model 1[a]	
	n	%	n	%	OR	95%CI	OR	95%CI	n	%	n	%	OR	95%CI	OR	95%CI
Never SA	76	7.2	984	92.8	*Ref*	-	*Ref*	-	46	4.3	1014	95.7	*Ref*	-	*Ref*	-
Remitted SA	0	0	5	100.0	-	-	-	-	1	20.0	4	80.0	5.51	0.60–50.29	5.93	0.56–62.90
Incident SA	3	13.6	19	86.4	2.04	0.59–7.06	1.94	0.56–6.73	5	22.7	17	77.3	**6.48**	**2.29–18.34**	**7.25**	**2.51–20.95**
Persistent SA (1)	0	0	7	100.0	-	-	-	-	1	14.3	6	85.7	3.67	0.43–31.15	4.39	0.47–1.33
Persistent SA (2)	0	0	6	100.0	-	-	-	-	0	0	6	100.0	-	-	-	-

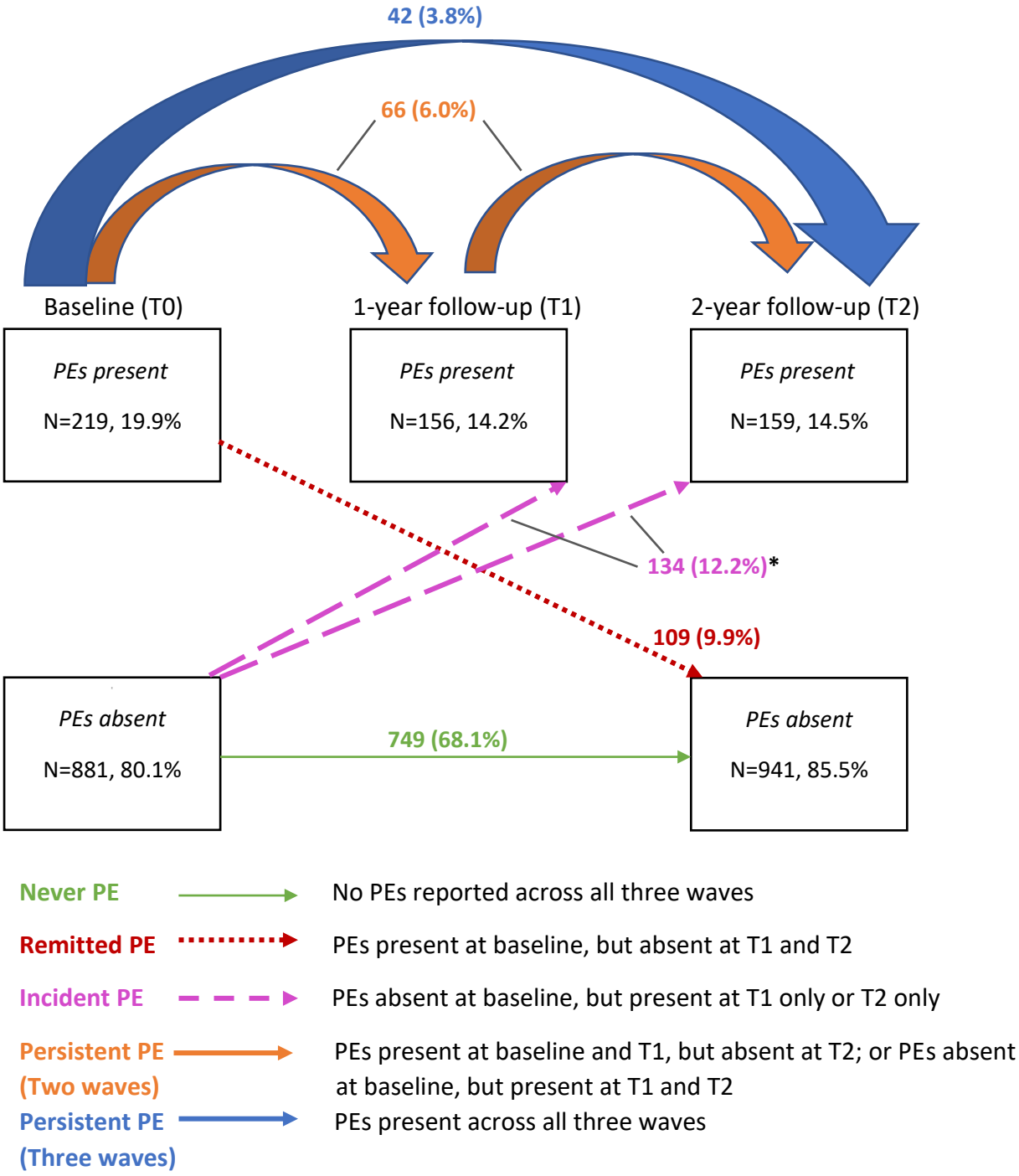
	Incident auditory HEs at 1-year follow-up								Incident auditory HEs at 2-year follow-up							
	Yes (n=32)		No (n=1068)		Unadjusted		Model 1[a]		Yes (n=18)		No (n=1081)		Unadjusted		Model 1[a]	
	n	%	n	%	OR	95%CI	OR	95%CI	n	%	n	%	OR	95%CI	OR	95%CI
Never NSSI	18	2.0	862	98.0	*Ref*	-	*Ref*	-	11	1.3	868	98.7	*Ref*	-	*Ref*	-
Remitted NSSI	0	0	14	100.0	-	-	-	-	0	0	14	100.0	-	-	-	-
Incident NSSI	6	6.3	90	93.7	**3.19**	**1.24–8.25**	**3.23**	**1.24–8.40**	3	3.1	93	96.9	2.55	0.70–9.29	2.40	0.65–8.87
Persistent NSSI(1)	1	2.0	48	98.0	1.00	0.13–7.63	1.16	0.15–8.95	3	6.1	46	93.9	**5.15**	**1.39–19.08**	**7.41**	**1.89–28.96**

Persistent NSSI(2)	7	11.5	54	88.5	**6.21**	**2.49–15.50**	**8.95**	**3.44–23.28**	1	1.6	60	98.4	1.32	0.17–10.36	1.86	0.23–15.15

	Incident auditory HEs at 1-year follow-up								**Incident auditory HEs at 2-year follow-up**							
	Yes (n=32)		**No (n=1068)**		**Unadjusted**		**Model 1[a]**		**Yes (n=18)**		**No (n=1081)**		**Unadjusted**		**Model 1[a]**	
	n	**%**	**n**	**%**	**OR**	**95%CI**	**OR**	**95%CI**	**n**	**%**	**n**	**%**	**OR**	**95%CI**	**OR**	**95%CI**
Never SA	29	2.7	1031	97.3	*Ref*	-	*Ref*	-	15	1.4	1044	98.6	*Ref*	-	*Ref*	-
Remitted SA	0	0	5	100.0	-	-	-	-	0	0	5	100.0	-	-	-	-
Incident SA	3	13.6	19	86.4	**5.61**	**1.57–20.04**	**5.95**	**1.65–21.43**	3	13.6	19	21.6	**10.99**	**2.94–41.14**	**13.7**	**3.48–53.99**
Persistent SA (1)	0	0	7	100.0	-	-	-	-	0	0	7	100.0	-	-	-	-
Persistent SA (2)	0	0	6	100.0	-	-	-	-	0	0	6	100.0	-	-	-	-

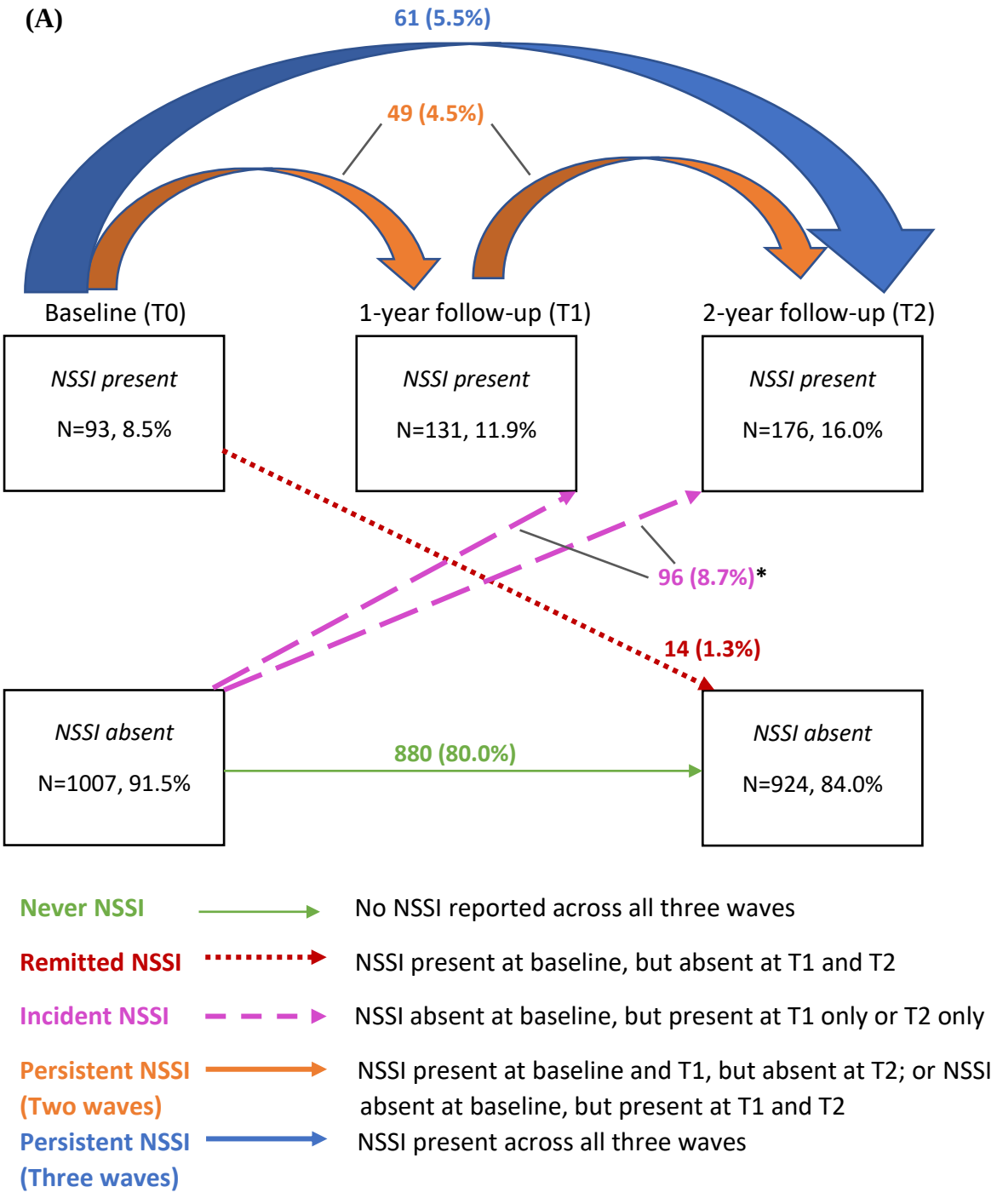
Note. Never NSSI/SA = NSSI or suicide attempt absent across all three waves of data; remitted NSSI/SA = NSSI or suicide attempt present at baseline only; incident NSSI/SA = NSSI or suicide attempt absent at baseline, but present at T1 or T2 only; persistent NSSI/SA – two waves = NSSI or suicide attempt present at baseline and T1 but absent at T2, or NSSI or suicide attempt absent at baseline but present at T1 and T2; persistent NSSI/SA – three waves = NSSI or suicide attempt present across all three waves; OR = odds ratio; 95%CI = 95% confidence interval; NSSI = non-suicidal self-injury; SA = suicide attempt; PEs = any psychotic experience i.e., auditory hallucinatory experiences, thoughts read, special messages received or spied-upon; HEs = auditory hallucinatory experiences.
Bold indicates significant odds ratio ($p < 0.05$). Linear trend in odds ratio (never>remitted>incident>persistent1>persistent2), as assessed using linear-by-linear associations (X^2), were significant for NSSI – incident PEs/HEs at T1; all other models were non-significant.
[a] Model 1: adjusted for sociodemographics (age, sex) and lifetime substance use (cannabis and other illicit substances).

Figure 1. Trajectories of psychotic experiences (PEs) across the three waves of data (n=1100)



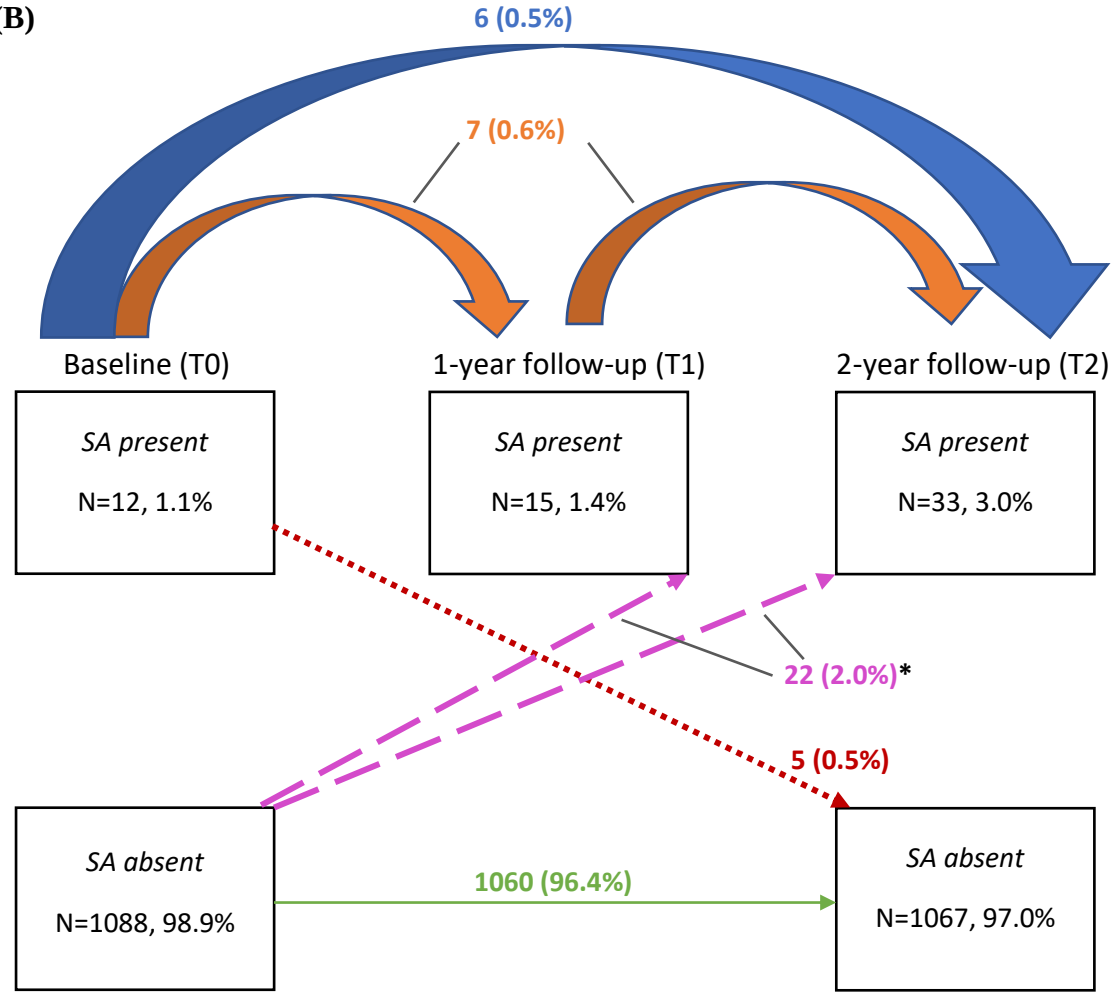
* Note. A small percentage of participants (2.8%) endorsed PEs at baseline AND T2 follow-up, but not at T1 follow-up. These participants were included as part of the 'incident PE' category; they did not warrant their own category and had minimal impact on the overall model.

Figure 2. Trajectories of **(A)** non-suicidal self-injury (NSSI) and **(B)** suicide attempts (SA) across the three waves of data (n=1100)



* Note. A small percentage of participants (0.8%) endorsed NSSI at baseline AND T2 follow-up, but not at T1 follow-up. These participants were included as part of the 'incident NSSI' category; they did not warrant their own category and had minimal impact on the overall model.

(B)



Never SA	No suicide attempts reported across all three waves
Remitted SA	Suicide attempts present at baseline, but absent at T1 and T2
Incident SA	Suicide attempts absent at baseline, but present at T1 only or T2 only
Persistent SA (Two waves)	Suicide attempts present at baseline and T1, but absent at T2; or suicide attempts absent at baseline, but present at T1 and T2
Persistent SA (Three waves)	Suicide attempts present across all three waves

* Note. A small percentage of participants (0.3%) endorsed suicide attempts at baseline AND T2 follow-up, but not at T1 follow-up. These participants were included as part of the 'incident suicide attempt' category; they did not warrant their own category and had minimal impact on the overall model.