Impact of change in insomnia on change in pandemic paranoia: a longitudinal moderated-mediation model in an international sample

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A B S T R A C T

The impact of mistrust of others during a pandemic is an important consideration for public health interventions. Pandemic paranoia is a particular form of persecutory thinking characterised by mistrust and suspicion towards other people specifically due to a pandemic. Pandemic paranoia is heightened among those with a persecutory thinking tendency. We examined the longitudinal relationship between insomnia and pandemic paranoia, with anxiety, depression, and worry as mediators and persecutory thinking as moderator. A longitudinal online survey design was utilized involving an international sample (N = 715) across two timepoints, 12 weeks apart. A moderated mediation model was tested, assessing the effect of change in insomnia on change in pandemic paranoia with changes in anxiety, depression and worry as mediators. The effect of persecutory thinking as a moderator was then tested on the above paths in relation to insomnia. Changes in insomnia predicted changes in pandemic paranoia. Change in anxiety was a significant mediator of insomnia's effects on pandemic paranoia: this indirect pathway was moderated by persecutory thinking. Changes in worry and depression were not significant mediators. Our findings indicate that insomnia influences pandemic paranoia, indirectly through anxiety; persecutory thinking plays a consequential role in these relationships. These findings suggest that special attention should be given to mitigation efforts during pandemics to promote sleep health in individuals with pre-existing vulnerabilities, such as persecutory thinking styles.

The increased uncertainty of the COVID-19 global pandemic has been associated with greater conspiratorial thinking and general paranoia in the community (Larsen et al., 2021), which appear to play a role in influencing health attitudes, such as willingness to take vaccines (Lincoln et al., 2022). Unwarranted suspicion that others are deliberately engaged in personally harmful actions related to the pandemic is a particular type of persecutory thinking described as *pandemic paranoia* (Kingston et al., 2021). Similar to paranoid thinking in general, pandemic paranoia ranges from suspicions that are commonly held, including being unable to trust others will follow social distancing rules, to conspiracy thinking about how powerful others are using the pandemic for their own malign purposes, through to persecutory ideas about people transmitting infectious disease deliberately to cause harm

to oneself (Kingston et al., 2021).

Pandemic paranoia has been observed to be prevalent across diverse, international populations (overall prevalence rate 19 %: Ellett et al., 2022) and is associated with general paranoid thinking, showing a similar hierarchical structure (Kingston et al., 2021). Pandemic paranoia is associated with conspiratorial thinking and interpersonal mistrust (Kingston et al., 2021), influencing adherence to health behaviours such as vaccination and social distancing (So et al., 2022). Additionally, pandemic paranoia shows greater specificity in predicting COVID-19 preventative behaviours (Gaudiano et al., 2023), when compared to general paranoia and general distress. Finally, Gaudiano et al. (2023) found that the effect of general paranoia on lower vaccine willingness was explained through higher levels of pandemic paranoia conspiracy

thinking, and lower levels of interpersonal mistrust and persecutory threat.

Pandemic paranoia may additionally account for how people high in mistrust respond to a pandemic. People with high general paranoia may be more likely to respond to global pandemic threats with suspicious thinking: So et al. (2022) found through a latent class analysis that people reporting high pandemic paranoia tended to also have a high endorsement of general paranoid thinking. Notably, individuals who displayed a tendency of general paranoid thinking (with or without pandemic paranoia) reported more marked worry and more negative self and other beliefs than healthy controls. However, those with pandemic paranoia showed less engagement in pro-health behaviours and greater positive-self beliefs than those who had general paranoid thinking alone but without pandemic paranoia (So et al., 2022).

Studies of general paranoia have identified influential roles for insomnia, negative affect, and worry in the incidence and maintenance of paranoid thinking (Freeman et al., 2009, 2012; Hennig et al., 2020; Kasanova et al., 2020; Scott et al., 2017). These psychological factors may also be influential for pandemic paranoia. Further, it is of interest to understand if *changes* in levels of these variables influence pandemic paranoia over time. Further, this study will focus on the impact of changes in persecutory ideation, an indicator of more severe paranoia rather than ideas of social reference (Freeman et al., 2021a,b).

We will outline what is currently understood about the impacts of these changes for paranoia, with the intention of presenting a model of these relationships for pandemic paranoia, to inform the hypotheses of the current study.

1. Insomnia

Insomnia plays an important role in paranoid thinking (Kasanova et al., 2020), with this link reported across multiple studies (Hennig and Lincoln, 2018; Kammerer et al., 2021). There are indications that insomnia influences the onset of paranoid thinking (Reeve et al., 2015); longitudinal studies demonstrate that changes in insomnia are impactful on subsequent paranoid thinking (Freeman et al., 2010; Kammerer et al., 2021). Sleep loss has been shown to be a pre-cursor to paranoid thinking (Reeve et al., 2018a,b). Improving sleep quality results in reductions in paranoia for both clinical (Freeman et al., 2021a,b; Sheaves et al., 2019) and non-clinical populations (Freeman et al., 2017). While there are clear indications that the impact of changes in insomnia on general paranoia is consequential, it is unknown whether a similar relationship is observed with pandemic paranoia.

2. Negative emotions and insomnia

Insomnia is also associated with predictors of paranoid thinking, such as anxiety, depression and worry (Freeman et al., 2012). There are indications that the impact of poor sleep quality on paranoia is mediated by negative affect (Hennig and Lincoln, 2018; Kasanova et al., 2020). Negative emotions (depression and anxiety) have also been found to mediate the relationship between insomnia and general paranoia (Freeman et al., 2009; Mulligan et al., 2016; Reeve et al., 2018a,b). More broadly, negative emotions are implicated in the hyper-arousal models of insomnia (Harvey, 2002; Riemann et al., 2010).

Longitudinal studies show that insomnia symptoms precede the development of anxiety and depressive symptoms (e.g., Baglioni et al., 2011; Hertenstein et al., 2019; Johansson et al., 2021). When paranoid thinking has been studied as a dependent variable in longitudinal studies, increases in depression, anxiety and worry predict later paranoia in both clinical and non-clinical samples (Freeman et al., 2012; Kramer et al., 2014; So et al., 2018; Vorontsova et al., 2013).

3. Worry

Worry has been identified as a predictor for paranoia (Freeman et al.,

2010). It has been observed that high levels of worry are exacerbated for people with paranoia and anxiety compared those who are anxious but do not have persecutory thinking (So et al., 2018). Longitudinally paranoia and anxiety appear to co-vary and influence each other, in contrast, worry has not been observed to independently predict paranoia over time (Sun et al., 2019). Recent reviews of intensive longitudinal studies of the relationship of worry with paranoia suggest that there remain questions about directionality of influence and the presence of third variables for clinical samples (e.g., Lüdtke et al., 2023).

It may be that similar sleep, emotional and negative thinking processes can be observed with pandemic-specific suspicions, over time. The role of co-occurring persecutory thinking in influencing how these processes impact pandemic paranoia over time is therefore of interest.

4. Study aims

In the current study we explore a new area in understanding pandemic paranoia: observing over time how changes in pandemic paranoia may be influenced by changes in insomnia, and investigating potential mediating effects of changes in anxiety, depression and worry in the insomnia-pandemic paranoia association. Since persecutory thinking has been shown to contribute to pandemic paranoia, it is entered as a moderator in the relationship between insomnia and pandemic paranoia, yielding a moderated-mediation model (see schematic diagram of this statistical model in Fig. 1). Based on the literature presented above we predicted.

1. Changes in insomnia from Time 1 (T1) to Time 2 (T2) will predict changes in pandemic paranoia.
2. Changes in the relationship of insomnia on pandemic paranoia from Time 1 (T1) to Time 2 (T2) will be mediated by changes in anxiety, worry and depression.
3. The influence of the direct and indirect pathways on change scores will be moderated by persecutory thinking.

5. Method

5.1. Design

The study used a longitudinal survey design across two timepoints, 12 weeks apart (T1-T2: Δ). The outcome variable was change in pandemic paranoia. The hypothesised predictor variable was change in insomnia, the proposed mediators were changes in depression, anxiety and worry and the proposed moderator of the mediation pathway was differing levels of changes in persecutory thinking.

5.2. Participants

The sample was recruited for an international survey study of pandemic paranoia (see Kingston et al., 2021 for details of the main study). The study sample were participants who responded to emails from the researchers to complete a second set of measures 12 weeks after T1 measures had been completed. T1 recruitment for the international survey study was conducted in February to April 2021 across five sites (UK, USA, Hong Kong, Germany and Australia). The inclusion criteria were those aged 18 and above and residing in the geographic region of the respective study site. There were no exclusion criteria. Sampling stratification (by age, gender, and education level) was applied by referencing local census data (total Time 1 sample across regions N = 2510).

5.3. Measures

Participants provided demographic information about their age, gender identity, education level, income, employment status, whether they identified as belonging to a minority group, and whether they had a
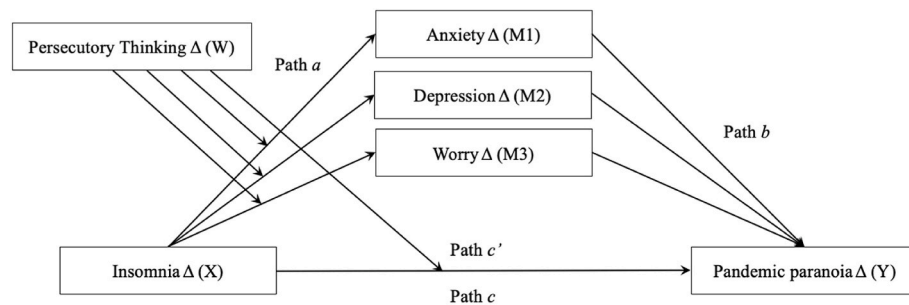
Fig. 1. Study moderated-mediation statistical model of the effect of change in insomnia on change in pandemic paranoia (T1-T2: Δ).
Note: This figure presents the change scores (Δ) variables in their hypothesised relationships for the model. X – predictor; Y – dependent variable; M – mediator; W – moderator; Δ – time 1- time 2 change.

trauma history.

The following self-report measures were used within the Time 1 and Time 2 surveys:

The *Insomnia Severity Index* (ISI; Bastien et al., 2001) is a 7-item measure assessing the severity and impact of insomnia over the past month. Items are rated from 0 (no problem) to 4 (very severe problem), with total scores ranging from 0 to 28. It evaluates sleep onset, sleep maintenance, sleep dissatisfaction, interference with daytime functioning, and distress caused by sleep difficulties. The ISI demonstrates good psychometric properties, with a Cronbach's alpha of .91 in our sample.

The *Pandemic Paranoia Scale* (PPS; Kingston et al., 2021) uses 25 items rated on a 5-point scale (0–4) to measure paranoia related to the COVID-19 pandemic, yielding a total score (0–100) and three subscales: persecutory threat (e.g., "People are deliberately trying to pass COVID-19 to me"), interpersonal distrust (e.g., "I can't trust others to stick to the social distancing rules"), and paranoid conspiracy (e.g., "The government is using the COVID-19 pandemic to control us"). This study used the total PPS score. The PPS shows good internal consistency with a Cronbach's alpha of .93 in this sample.

The *Depression Anxiety and Stress Scales-21* (DASS-21; Lovibond and Lovibond, 1995) is a 21-item measure of anxiety, depression and stress. Participants rate symptoms on 4-point scales (0–3). The DASS-21 shows good psychometric properties; this study used the Anxiety and Depression sub-scales (Cronbach's alpha: Anxiety .88; Depression .94).

The *Revised Green Paranoid Thoughts Scale* (R-GPTS; Freeman et al., 2021a,b) is an 18-item measure of paranoid thinking rated on a 5-point scale (0–4). It has two sub-scales, ideas of reference (8 items) and persecutory thinking (10 items). This study used the persecutory thinking subscale. The R-GPTS shows good internal consistency with this sample (Kingston et al., 2021); Cronbach's alpha in this study: Reference .91, Persecution .95.

The *Penn State Worry Questionnaire*, ultra-brief version (PSWQ-3; Berle et al., 2011) is a 3-item measure of pathological worry. Items are rated from 1 (not at all typical) to 5 (very typical), with higher total scores indicating higher trait worry. The PSWQ-3 shows excellent psychometric properties, similar to the full PSWQ. Cronbach's alpha in our sample is .90.

5.4. Procedure

Ethical approval was obtained from each of the five host sites. Potential participants were recruited using Qualtrics panel survey: upon giving their consent they completed the Time 1 (T1) survey; participants were asked to provide a follow-up email if they were interested in taking part in a second survey 12 weeks later.

The participants completed an online survey hosted on the Qualtrics platform, with survey responses linked through email addresses. Each site conducted its own panel survey and Time 2 (T2) assessment. The T2 data set was then created from de-identified data shared by the researchers across sites. Participants' T2 data was linked with their T1 scores.

For the T1 survey, participants were compensated for completion through the Qualtrics panel process; for the T2 survey participants were reimbursed either: 1) by direct remuneration for completing the survey (Hong Kong), or 2) with the opportunity to register for a prize draw following survey completion (Australia, USA, UK, Germany), managed by the research teams at each site.

5.5. Data analysis

The study sample was compared to the full T1 sample from Kingston et al. (2021) to assess any significant differences in demographic characteristics. Comparisons were then conducted between T1 and T2 scores using t-tests, and effect size estimates were calculated.

For the test of the model presented in Fig. 1, all analyses were conducted using the PROCESS macro for SPSS (Hayes, 2013) with T1 variables entered as co-variates, relevant to the analysis (insomnia, persecutory thinking, pandemic paranoia, worry, anxiety, depression), and percentile 95 % confidence intervals (bootstrap samples N = 5000). The model assessment was planned across three steps: Firstly, a simple moderation analysis of the T2 insomnia – T2 pandemic paranoia relationship, with T2 persecutory thinking as a moderator (PROCESS Model 1). Secondly, a parallel mediation analysis of the T2 insomnia – T2 pandemic paranoia relationship, with potential mediators T2 anxiety, worry and depression (PROCESS Model 4). Finally, the hypothesised moderated mediation model was conducted using the PROCESS macro for SPSS model 8. This assessed the significance of each of the indirect effects (path-a anxiety, depression, worry: see Fig. 1) at differing standard deviation levels of the moderator (persecutory thinking), deriving indices of moderated mediation (Hayes, 2015). Moderation analyses were probed for significant interactions using the Johnson-Neyman technique (Hayes, 2013; Preacher et al., 2007).

6. Results

6.1. Sample characteristics

Participants (N = 715) were recruited from the following sites: the United Kingdom (N = 98), United States of America (N = 161), Australia (N = 94), Hong Kong (N = 296), and Germany (N = 66).

The demographics for the study sample are presented in Table 1. When compared to the total T1 sample from Kingston et al. (2021), the study sample participants were older; had similar gender proportions; had a greater proportion of university graduates; had a smaller proportion of those with lower incomes; had a smaller proportion of those working part-time, but no differences in those unemployed or disabled. There were no differences between study participants and T1-only for minority status. There was a lesser proportion of participants in the study sample who reported a trauma history.

Table 1
Demographics of study participants.

Variable	Category	Frequency	Percentage
Age	M (SD)	47.92 (15.4)	
	Range	18–87	
Gender	Male	314	43.9
	Female	401	56.1
Education	Primary	14	2.0
	Secondary or equivalent	153	21.3
	A-level or equivalent	205	28.7
	Bachelor degree or equivalent	255	35.7
	Masters degree or equivalent	78	10.9
	PhD or equivalent	11	1.5
Income	Under £18 500	110	15.4
	£18 500–36 999	197	27.6
	£37 000–55 999	170	23.8
	£56 000–74 999	76	10.6
	£75 000–92 999	71	9.9
	£93 000–111 999	43	6.0
	£112 000+	48	6.7
Employment	Full-time	374	52.3
	Part-time	89	12.4
	Retired	63	8.8
	Unemployed (looking)	23	3.2
	Unemployed (not looking)	57	8.0
	Home keeper/carer	31	4.3
	Disabled	26	3.6
	Training/school	52	7.3

The within-participant changes for the study sample are presented in Table 2. Compared to T1, at T2 participants reported a significant increase in anxiety ($p < .010$), and reductions in levels of worry and persecutory thinking ($ps < .010$). There were no significant changes in sleep quality, or levels of depression and pandemic paranoia at T2 ($ps > .050$).

6.2. Moderation analysis

A simple moderation analysis, based on 5000 bootstrapped samples, controlling for T1 covariates, did not reveal a significant moderating impact for T2 persecutory thinking on the relationship between insomnia T2 and pandemic paranoia T2 (b = .006, SE = .006, p = .296, 95 %CI[-.005, .017]. In the regression, combined with T1 covariates, both insomnia T2 (b = .247, SE = .097, p = .011, 95 %CI[.056, .437]) and persecutory thinking T2 (b = .530, SE = .101, p < .001, 95 %CI [.332, .728]) were predictors for pandemic paranoia T2: Full model – R^2 = .604, F = 180.010 (6, 708), p < .001.

6.3. Mediation analysis

A mediation analysis, based on 5000 bootstrapped samples, controlling for T1 covariates, assessed the parallel mediating roles of anxiety, depression and worry on the relationship between insomnia and pandemic paranoia. The results the direct effect of T2 insomnia was found to be significant on T2 pandemic paranoia (b = .344, SE = .098, p < .001, 95 %CI[.152, .536]). Significant indirect effects were found for

T2 anxiety (b = .482, SE = .138, p < .001, 95 %CI[.210, .753]) and T2 worry (b = .447, SE = .172, p = .009, 95 %CI[.110, .785]) on T2 pandemic paranoia. Depression (b = −.195, p = .137) was not found to be a significant mediator. Full model – R^2 = .561, F = 99.903 (9, 705), p < .001.

6.4. Moderated mediation analyses

Fig. 2 presents the paths and coefficients for the moderated mediation analysis.

Results based on 5000 bootstrapped samples indicated that, controlling for the effects of T1 covariates, there was no direct effect (b = .194, SE = .101, p = .055 95 %CI[-.004, .392]) of changes in insomnia on changes in pandemic paranoia. The overall insomnia x persecutory thinking interaction effect was also non-significant (Interaction = .004, SE = .006, p = .516. 95 %CI[-.008, .015]).

Each of the path-a mediator analyses presented in Fig. 2 are reported below.

Insomnia - > Anxiety - > Pandemic Paranoia

The a-path from insomnia to anxiety was significant, b = .191, SE = .044, p < .001, 95 %CI[.105, .277]. For the a-path from insomnia to anxiety there was a significant interaction between insomnia and persecutory thinking, b = .012, SE = .003, 95 %CI[.007, .017], p < .001, ΔR^2 = .021. The conditional indirect effect for insomnia on anxiety was strongest for high values (+1 SD) of persecutory thinking, b = .365, SE = .043, 95 %CI [.280, .450], weaker but still significant for medium values, b = .260, SE = .040, 95 %CI[.182, .338], and small values (−1 SD) of persecutory thinking, b = .191, SE = .044, 95 %CI [.105, .277]. The Johnson-Neyman method did not find any significant transition points.

The b-path from anxiety to pandemic paranoia was significant, b = .390, SE = .131, p < .003, 95 %CI[.133, .647]. Conditional indirect effects for anxiety as a mediator were significant, index of moderated mediation = .005, 95 %CI [.001, .009].

Insomnia - > Depression - > Pandemic Paranoia

The a-path from insomnia to depression was significant, b = .182, SE = .047, p < .001, 95 %CI[.090, .275]. The was a significant interaction for the effect of insomnia conditional on levels of persecutory thinking on the a-path to depression, b = .012, SE = .003, p < .001, 95 %CI[.006, .017]. The conditional indirect effect for insomnia on depression was strongest for high values (+1 SD) of persecutory thinking, b = .349, SE = .046, 95 %CI [.258, .441], weaker but still significant for medium values, b = .249, SE = .043, 95 %CI[.165, .332], and small values (−1 SD) of persecutory thinking, b = .182, SE = .047, 95 %CI [.090, .275]. The Johnson-Neyman method did not find any significant transition points.

The b-path from depression to pandemic paranoia was non-significant, b = −.215., SE = .124, p = .082, 95 %CI[-.458, .027]. Indirect effects conditional on persecutory thinking were not observed with depression, index of moderated mediation = −.003, 95 %CI [-.006,

Table 2
Time 1 and time 2 scores for study measures.

Study Measure	Time 1		Time 2		$t(714)$	p	Cohen's d 95 %CI
	M	SD	M	SD			
ISI	8.87	6.51	8.59	6.43	1.885	.088	−.010, .137
DASS- Anxiety	4.69	4.86	5.20	5.03	−2.580	.010	−.170, −.023
DASS-Depression	6.15	6.07	6.47	5.88	−1.573	.116	−.023, .015
PSWQ-3	7.83	3.51	7.48	3.52	3.770	<.001	.067, .215
RGPTS -Persecution	6.35	9.16	5.62	8.54	2.924	.004	.036, .183
PPS Total	13.45	14.56	12.98	14.58	1.145	.253	−.031, .116

Note. ISI – Insomnia Severity Index; DASS – Depression Anxiety Stress Scales-21; PSWQ-3 - Penn State Worry Questionnaire-3 item; R-GPTS – Revised Green Paranoid Thoughts Scale; PPS - Pandemic Paranoia Scale.
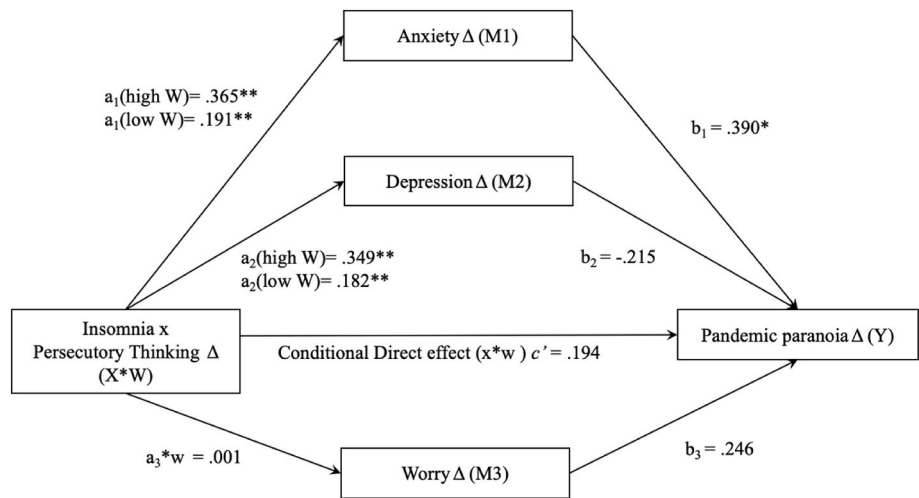
Fig. 2. Moderated-mediation model of the effect of change in insomnia on change in pandemic paranoia, conditional on persecutory thinking (Δ).
Note: a = conditional effect of X on M (high = + 1 SD, low = −1 SD of the moderator); b = the effect of M on Y in the context of the other mediators. Individual indirect effects = a x b.*p < .001.

.001]

Insomnia - > Worry - > Pandemic Paranoia

The a-path from insomnia to worry was significant, $b = .126$, SE = .023, p < .001, 95 %CI[.081, .172]. The interaction of insomnia conditional on levels of persecutory thinking on the a-path to worry was non-significant, $b = .001$, SE = .001, p = .820, 95 %CI[-.002, .003].

The b-path from worry to pandemic paranoia was non-significant, $b = .246$, SE = .163, p = .132 95 %CI[-.075, .567]. Indirect effects conditional on persecutory thinking were not observed with worry, index of moderated mediation = .000 (95 %CI = −.001, .001).

For the full regression results see Table 3.

7. Discussion

In this study, we engaged an international sample to report on their experiences after a three-month period, to observe changes in pandemic paranoia (concerns of harm from others related to the pandemic) and investigate a hypothesis-driven model of how insomnia may influence these changes. We hypothesised that changes in anxiety, worry and depression played a mediatory role in the insomnia-pandemic paranoia relationship, conditional on the strength of persecutory thinking (a moderated mediation model).

We found that increases in insomnia were associated with increases in pandemic paranoia. However, this relationship was not conditional on changes in levels of persecutory thinking (the simple moderation analysis). We also found significant direct and indirect pathways (through anxiety and worry, but not depression) for the insomnia-pandemic paranoia relationship in a parallel mediation analysis.

When these variables were combined in the study model, we found that anxiety was the sole significant mediator for how insomnia influenced pandemic paranoia, with this indirect pathway also influenced by levels of persecutory thinking. The direct effect of changes in insomnia on changes in pandemic paranoia were found to be non-significant. We observed that when followed up after a 12-week period, for those participants reporting high levels of persecutory thinking, changes in insomnia impacted pandemic paranoia and this effect was fully accounted for by changes in anxiety, again, influenced by persecutory thinking. These findings suggest that persecutory thinking plays a consequential role in how insomnia influences pandemic paranoia, through an indirect pathway of anxiety.

The current study extends So et al.'s (2022) latent class analysis findings of the relationships between pandemic paranoia being associated with paranoid thinking in general (using the larger T1 sample). In this study we demonstrated across a three-month period that persecutory thinking exerted an influence on how anxiety accounts for the impact of sleep on pandemic paranoia. Our findings support previous observations about the role of sleep in suspicious thinking (Kasanova et al., 2020) and extends to particular suspicions related to others' actions in the pandemic. Beyond cross-sectional observations of the sleep-paranoia association, this study provides further evidence of how changes in sleep quality co-occur with both changes in pandemic paranoia and persecutory thinking. This is also consistent with studies showing that sleep disturbance is associated with increased anxiety (a bidirectional relationship; Alvaro et al., 2013). While associations between sleep, anxiety, worry and depression were observed within the sample over time, it appears that when understanding the impact of sleep on suspicious thinking related to the pandemic, anxiety was the significant mediator (conditional upon persecutory thinking).

Our hypothesised model incorporating anxiety, worry and depressive symptoms in mediating the influence of sleep on pandemic paranoia was partially supported: worry and anxiety were found to be mediators, along with anxiety, in the parallel mediation model. However, when the

Table 3
Regression results for the moderated mediation model.

Variable	Model a-path			Model b-path		
	b	SE	p	b	SE	p
Mediator: Anxiety				.390	.101	.003
Insomnia (IV)	.191	.044	<.001			
Persecutory Thinking (Mod)	−.071	.045	.114			
Insomnia x Persecutory Thinking (Int)	.012	.003	<.001			
Mediator: Worry				.246	.163	.132
Insomnia (IV)	.126	.023	<.001			
Persecutory Thinking (Mod)	.059	.024	.013			
Insomnia x Persecutory Thinking (Int)	.0001	.001	.820			
Mediator: Depression				−.215	.124	.082
Insomnia (IV)	.182	.047	<.001			
Persecutory Thinking (Mod)	−.064	.048	.185			
Insomnia x Persecutory Thinking (Int)	.012	.003	<.001			

N = 715. Model c' path R^2 = .612, F(12, 702) = 92.316, p < .001.
Direct effect, $b = .194$, SE = .101, p = .055, 95 %CI[-.0046, .392].

moderating influence of persecutory thinking on the indirect pathway was included in the model, worry was not found to be a mediator. This finding is in contrast with studies observing relationships for worry and depression in changes of levels of general paranoia (Kramer et al., 2014; Reeve et al., 2018a,b), albeit over shorter time periods (two weeks) than the current study (12 weeks). Similarly, compared to So et al. (2022) where worry predicted latent class membership for higher pandemic and general paranoia, the current study did not show a significant role of worry as a mediator in fluctuations of insomnia and pandemic paranoia over the three-month study period, when persecutory thinking is accounted for as a moderator of the indirect pathway. It may be, when considered in combination longitudinally over longer periods, insomnia is associated strongly with anxiety, and that this is a specific pathway to changes in pandemic paranoia.

Our study findings suggest that the presence of persecutory thinking appears to intensify the impact of the insomnia-anxiety relationship on pandemic paranoia over time. It is recognised that sleep, negative affect and worry are likely to have bidirectional relationships over time (Hennig et al., 2020; Kasanova et al., 2020). These psychological factors also have linkages at a neurophysiological level, with poor sleep quality and anxiety involving increasing connectivity involving the limbic system and pre-frontal cortex (e.g., Prather et al., 2013; Shen et al., 2023); similarly so for persecutory thinking (e.g., Pinkham et al., 2022; Fan et al., 2021; Walther et al., 2022). A future direction for research is to investigate differences and connections at a neurophysiology related to pandemic and general paranoia.

Given the social and personal challenges of pandemic management, an implication from these findings is that providing greater support to improve sleep quality for vulnerable groups (Morin and Jarrin, 2022), such as those with increased persecutory thinking may be especially important, particularly if preventive strategies to reduce viral transmission such as lockdown/confinement are used, which can impact on sleep quality, mood and anxiety (Morin et al., 2021). Additionally, a future research direction will be to observe whether the structure and prevalence of the pandemic-specific paranoia found in the COVID-19 pandemic (Kingston et al., 2021; Ellett et al., 2022) is generalizable to understanding interpersonal mistrust and conspiracy thinking in future pandemics, and whether there are similar associations with sleep, anxiety and general paranoia.

7.1. Strengths and limitations

A strength of this study is the longitudinal design, allowing investigation of changes within participants across two time-points. This enabled us to observe how changes in sleep and other variables impacted changes in pandemic paranoia, linked to individual participants. The study period of three months enabled an investigation of medium-term changes in sleep and pandemic paranoia. A further strength is that the statistical approach we used controlled for a group of interrelated variables, allowing for the identification of unique variance in the relationships tested.

A limitation is the nature of the sample engaged in this study, constituting an uneven grouping of participants from the regions of the T1 assessment for the pandemic paranoia study (Ellett et al., 2022). The proportions of participants from the regions differed, in comparison to the equal proportions in the T1 study. The study participant group was found to be different from the larger T1 sample in terms of demographics, with a greater proportion of female participants and those who reported trauma histories. The current study findings may be influenced by participant characteristics (i.e., those more likely to complete a second survey) and therefore our findings may not generalise to people who do not share these demographics. Finally, although we used a longitudinal design, it consisted of only two assessment periods, so that directionality in how changes occur could not be assessed, such as whether changes in insomnia precede changes in pandemic paranoia, vice-versa, or a co-varying relationship.

8. Conclusion

In summary, this study demonstrates that for a diverse international sample, changes in concerns about others' harmful actions related to a pandemic (pandemic paranoia) over a three-month period were influenced by changes in insomnia, and that changes in anxiety partially mediated this relationship, at different levels of persecutory thinking. The impact of mistrust of others during a pandemic may be an important consideration for public health interventions, particularly if mitigation efforts are associated with increased sleep disturbance and anxiety for individuals.

CRediT authorship contribution statement

Eric M.J. Morris: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Jessica Kingston:** Writing – review & editing, Methodology, Investigation. **Lyn Ellett:** Writing – review & editing, Methodology, Investigation. **Tania Lincoln:** Writing – review & editing, Methodology, Investigation. **Brandon A. Gaudiano:** Writing – review & editing, Methodology, Investigation. **Suzanne H. So:** Writing – review & editing, Writing – original draft, Methodology, Investigation.

Ethics approval and consent

See Procedure.

Data availability

Data enquiries should be made to the corresponding author.

Support

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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