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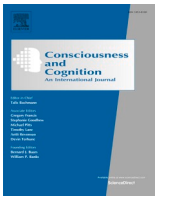

Viral simulations in dreams: The effect of the COVID-19 pandemic on threatening dream content in a Finnish sample of diary dreams

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ABSTRACT

Previous research indicates that the COVID-19 pandemic has affected dreaming negatively. We compared 1132 dreams collected with prospective two-week dream diary during the pandemic to 166 dreams collected before the pandemic. We hypothesized that the pandemic would increase the number of threatening events, threats related to diseases, and the severity of threats. We also hypothesized that dreams that include direct references to the pandemic will include more threatening events, more disease-related threats, and more severe threats. In contradiction with our hypotheses, results showed no differences between pandemic and pre-pandemic samples in the number of threats, threats related to diseases, or severe threats. However, dreams with direct references to the pandemic had more threats, disease-related threats, and severe threats. Our results thus do not suggest a significant overall increase in nightmarish or threatening dream content during the pandemic but show a more profound effect on a minority of dreams.

1. Introduction

In December 2019 a new SARS-CoV-2 virus was discovered in Wuhan, China, and the official WHO announcement regarding the novel virus was made on January 9, 2020. The virus causes the COVID-19 disease, transmitted both airborne and via touch. By spreading quickly, the virus caused a pandemic. Consequently, most countries applied restrictive measures to stop or hinder the spreading of the virus (Hale et al., 2021).

Various studies have found that fear of the COVID-19 disease and the restrictive measures, such as lockdowns and social distancing, have had a detrimental effect on the mental health of the general population (e.g. Salari et al., 2020). The impact was not, however, only limited to waking life. Numerous studies have been conducted to investigate the effects of the COVID-19 pandemic on dreams. Studies utilizing retrospective questionnaires or the most recent dream method have concluded that the pandemic increased dream recall (Conte et al., 2022; Meaklim et al., 2023; Scarpelli et al., 2021; 2022a; Schredl & Bulkeley, 2020; Simões et al., 2022) and

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negatively toned dreams and nightmares (Barrett, 2020; Conte et al., 2022; Giovanardi et al., 2021; Gorgoni et al., 2021; Meaklim et al., 2023; Parrello et al, 2021; Pesonen et al., 2020; Scarpelli et al., 2021, 2022a; Schredl & Bulkeley, 2020; Simões et al., 2022; Solomonova et al., 2021). People who were most affected by the pandemic (e.g., got ill, lost their job) reported stronger effects on their dreams (Scarpelli et al., 2021, 2022a; Schredl & Bulkeley, 2020). Women's dreams seemed to be more affected than men's (Barrett, 2020; Kilius et al., 2021; Parrello et al., 2021). However, the effects of the pandemic on dreams seemed to decrease with time (Parrello et al., 2021; Sommantico & Parrello, 2023).

Retrospective dream reporting measures, such as questionnaires and the most recent dream method, tend to lead to a strong memory bias both in terms of dream recall frequency and dream content, as they rely heavily on long-term memory. Thus, they may not accurately reflect the effects of the pandemic on dreaming but rather people's conceptions of such effects. Systematic prospective dream diaries, in contrast, yield less memory bias and therefore offer more reliable day-to-day information about dreams (Montangero et al., 1996; Zadra & Donderi, 2000). Yet, relatively few studies have been conducted on the effects of the COVID-19 pandemic on dreams utilizing prospective dream diaries. MacKay and DeCicco (2020) found, in 2-week dream diaries of Canadian students collected before and during the very early stages of the pandemic, that the pandemic sample had increased amounts of imagery related to the virus and restrictive measures (e.g., coughing, isolation). They interpreted this to reflect an increased amount of waking life anxiety due to the spreading virus. Similarly, Scarpelli et al. (2022a) studied in a within-subject design how a full lockdown in Italy affected dreams by using a 2-week diary. The first dream diary week was during full lockdown and the second week after the restrictions were eased. They found that the participants had higher number of awakenings, more difficulties falling asleep, and higher dream recall and lucid dream frequency during lockdown. However, the qualitative features of dreaming (e.g., positive or negative emotions) did not differ between lockdown and post-lockdown periods. Mota et al. (2020) used natural language processing tools to examine the differences in dreams before and during the pandemic. The dreams were collected with a smartphone app immediately after the participants woke up. They found that dreams during the pandemic had more words reflecting anger and sadness and more words related to contamination and cleanliness.

According to the threat simulation theory (TST), dreams are an evolutionary adaptation (Revonsuo, 2000). Dreams evolved as simulations that creatively combine aspects of threatening situations stored in memory. In dreams, the perception and recognition of, and the appropriate responses to threatening situations can be practiced in a safe environment. As a result of this nocturnal training the individual's ability to detect and react to threatening situations in waking life is enhanced. This could have provided additional survival benefits and led to increased reproductive success in ancestral humans. In accordance with the TST, studies have found that the frequency of daytime threats, the severity of daytime threats (Bradshaw et al., 2016; Lafrenière et al., 2018) and daytime stress (Lafrenière et al., 2018) predict threats in dreams. Rumination of an intrusive thought in the evening has been shown to increase threats in dreams the following night (Feng & Wang, 2022). In one study it was found that 60.4 % of participants dreamt about an upcoming stressful exam during the preceding night (Arnulf et al., 2014). Auschwitz survivors dreamt more about threatening events during the war than before or after the war (Bergman et al., 2020) and children who were severely traumatized by war had more threats in their dreams compared to less traumatized children or children with no exposure to war (Valli et al., 2005).

The threat simulation theory predicts that the threat simulation mechanism could be activated by novel threats, such as the COVID-19 pandemic. The more dangerous the threat is perceived to be, the more likely it is to be incorporated into dream content. In the early stages of the pandemic, the media coverage was more often negative than neutral or positive and seems to have sparked fear amongst the general public (Aslam et al., 2020). Media portrayed the COVID-19 disease as potentially severe to anyone, but especially to the elderly and people belonging to risk groups. This created significant worry even in healthy young individuals not belonging to risk groups (Barzilay et al., 2020). Although the mortality statistics later revealed that COVID-19 was extremely rarely deadly to healthy young individuals, COVID-19 remained potentially lethal to elderly people and people belonging to risk groups, creating worry in the population for the older relatives and risk group members. The restrictive measures taken in many societies to protect the most vulnerable, and to diminish the strain on the overburdened health care systems, left many people isolated or forced to work under risk of exposure to the virus (Sandford, 2020). Given societies were locally and globally heavily affected, this could have led to the activation of the threat simulation mechanism on an individual level. Thus, we could predict that the pandemic would have increased the number and severity of threatening events in dreams as well as led to a higher number of diseases and illnesses in dreams.

The effects of the pandemic on threatening dream content have been assessed in four studies. Wang et al. (2021) collected 91 dreams from undergraduates and postgraduates in Chinese colleges in February 2020 (i.e., during the first wave of the pandemic) using the most recent dream method and analysed the dreams with the Dream Threat Scale (Revonsuo & Valli, 2000). They compared these pandemic dreams to a sample of 91 dreams that were collected also with the most recent dream method in Chinese colleges in June 2019 (i.e., before the pandemic) for a prior study. They found an overall increase in the frequency of threatening events in the pandemic dreams but not in the frequency of threats related to diseases, illness, or medical problems. Koppehele-Gossel et al. (2023) investigated dreams collected with a prospective dream diary during two lockdowns in Germany and compared the findings to dreams collected before the pandemic. They analysed words related to threatening dream content and, in contrast to Wang et al. (2021), found no differences between the pandemic and pre-pandemic dream samples. Solomonova et al. (2021) found, utilizing an online survey and the Typical Dreams Questionnaire, filled between April 3 and May 15, 2020 by 968 (mostly) Canadian participants, that human threats (e.g., being chased, being attacked) were one of the most common themes in dreams during the pandemic. They also noted that higher stress levels, and greater symptoms of depression and anxiety, were associated with higher frequency of bad dreams, nightmares, and dreams about the pandemic. Yang et al. (2023) used the same Typical Dreams Questionnaire as Solomonova et al. (2021) when interviewing elderly Chinese between July 2021 and November 2022. They found that participants located in medium or high-risk areas for infection had more dreams about being chased compared to participants located in low-risk areas. In addition, the participants who were located in medium or high-risk areas experienced more fear in dreams compared to participants who were

located in low-risk areas.

While the findings of these studies lend partial support for the predictions of the threat simulation theory, the first one is based on a relatively small sample of dreams, the second on word-based automatic analysis, and the third and fourth on a retrospective survey or interview where dream content was not recorded. Further, the Typical Dreams Questionnaire does not include any items about illness or disease. Thus, the aim of the current study was to investigate, in a large Finnish sample of dreams collected with a prospective dream diary before and during the pandemic, whether COVID-19 pandemic affected dream content in a way predicted by the threat simulation theory. These predicted effects are an increase in the number of threatening events, an increase in the number of threats related to diseases, illness, or medical problems, and an increase in the relative number of severe threats in dreams reported during the pandemic compared to dreams reported before the pandemic. The threat simulation theory also predicts that dreams dreamt during the pandemic and that contain references to the pandemic (e.g., fear of crowded places, mentions about masks) are likely to reflect simulations of the novel threat. Thus, these dreams were predicted to have more threatening events, more threats related to diseases, illness, or medical problems, and more severe threats than dreams without references to the pandemic.

The six hypotheses of this study are:

H1: The COVID-19 pandemic has increased the number of threatening events in dreams dreamt during the pandemic compared to pre-pandemic dreams.
H2: The COVID-19 pandemic has increased the number of threats related to diseases, illness, or medical problems in dreams dreamt during the pandemic compared to pre-pandemic dreams.
H3: The COVID-19 pandemic has increased the relative number of severe threats to minor threats in dreams dreamt during the pandemic compared to pre-pandemic dreams.
H4: The dreams in the pandemic sample that contain direct references to the COVID-19 pandemic have a higher number of threatening events than dreams without references to the pandemic.
H5: The dreams in the pandemic sample that contain direct references to the COVID-19 pandemic have a higher number of threats related to diseases, illness, or medical problems than dreams without references to the pandemic.
H6: The dreams in the pandemic sample that contain direct references to the COVID-19 pandemic have a relatively higher number of severe threats to minor threats than dreams without references to the pandemic.

2. Material and methods

2.1. Participants

The pandemic sample consisted of 1132 dreams from 85 participants (4 men, 78 women, and 3 others; $M = 37.71$ years, $SD = 15.98$, range = 19–73). Email newsletters were sent to the student associations of almost all the major universities in Finland and through social media to recruit participants to the "Covid-on-Mind" study that was advertised to investigate the effects of the coronavirus pandemic on mind as assessed through well-being measures, and dream and mind-wandering reports. The study also got coverage in the Finnish mainstream media, which helped to recruit participants from the general population. The data were collected between 16th of April 2020 and 11th of June 2020, that is, in the middle of the first wave of COVID-19 pandemic in Finland when restrictive measures were the strictest. The participants did not receive monetary compensation for their participation and had the right to discontinue their participation at any time for any reason. Given all data were collected anonymously, the study procedure did not require ethical pre-evaluation according to the guidelines of the Finnish National Board on Research Integrity.

The pre-pandemic sample consisted of 166 dreams from 14 participants (7 men, 7 women; $M = 26.21$ years, $SD = 6.39$, range = 21–47). The participants for the pre-pandemic sample were recruited similarly through email newsletters sent to different student associations at the University of Turku, for another study that took place before the pandemic and focused on social aspects of dreaming (Tuominen, in preparation). The data were collected between November 2016 and January 2017. All the participants who completed the whole study were compensated 200 euros for their participation.

2.2. Procedure

2.2.1. The pandemic sample

During the data collection many restrictions were in place in Finland (Hale et al., 2021). Schools (not including early education) and government-run public facilities (theatres, libraries, museums, etc.) were closed. Critical personnel were exempted from the Working Hours Act and Annual Holidays Act, both in the private and public sector. Gatherings were restricted to 10 people. People over 70 years of age were advised to avoid all human contact if possible (excluding co-habitants). Visitors were forbidden from healthcare facilities and hospitals, excluding relatives of critically ill people and children. Citizens or permanent residents returning to Finland from abroad were placed under a 2-week quarantine.

The participants interested in the study were directed to the study's website (utu.fi/mind). To enroll, the participants read the general instructions about the study, indicated their consent to participate, and retrieved their personal participant identification numbers provided by a page counter visible in the ID subpage. The personal ID number guaranteed anonymity and enabled combining responses from the same participant. In the first part of the study, the participants filled in, via an internet-based survey tool (Webropol Surveys, https://www.webropol.com), a general well-being survey containing questions about psychological well-being, sleep quality, dream experiences, and COVID-19 related experiences. After this, the participants carried out two daily tasks over a 2-week period (14

days): a mind-wandering task in the evening and a daily dream diary in the morning. Only results pertaining to the dream diaries are presented in the current article.

In the dream diary task, the participants were asked to write down all the dreams they remembered from the previous night. The participants were asked not to remove or add anything to the dream reports and to be as precise and truthful as possible. In addition to the dream report, the participants were asked about positive and negative affect they experienced in the reported dream on a five-point Likert scale and how many people they had been in contact with the previous day on a five-point scale from none to over 25 people. If the participant recalled more than one dream from the same night, each dream and responses to the evaluative questions were reported separately. In the mind-wandering task, the participants were asked to stay still for 10 min in a quiet place in the evening and let their minds wander freely. After this they were asked to write down everything that went through their minds during that time. In addition, the participants were asked about positive and negative affect they experienced during the mind-wandering on a five-point Likert scale. They also answered a more detailed questionnaire about their emotions earlier during the day and responded to COVID-19 related questions (e.g., daily worry, time of consuming media concerning COVID-19). Dream and mind-wandering reports, and all the additional questions were collected using internet-based survey tool (Webropol Surveys).

In total, 297 participants submitted 1534 dream and 1251 mind-wandering reports. Only data from the participants who provided informed consent, filled in the well-being survey, reported at least 5 dreams, and completed at least 5 mind-wandering tasks, were included in the current study ($N = 85$). These participants reported on average 13.32 dreams ($SD = 6.88$, range = 5–40), and altogether 1132 dreams, during the two-week diary period.

2.2.2. The pre-pandemic sample

The potential participants interested in the original study first filled in, via an internet-based survey tool (Webropol Surveys), the Pittsburgh Sleep Quality Index -questionnaire (PSQI) (Buysse et al., 1989). The questionnaire measures sleep quality over the past month. Of the 92 persons enrolled in the study, 16 (8 males and 8 females) were selected based on the highest scores in PSQI. This was to ensure a sample of good sleep quality without sleep disorders.

In the pre-pandemic sample, dream and mind wandering reports were collected similarly as in the pandemic sample and with identical instructions, for two weeks. The participants also filled in questionnaires related to well-being and social relationships. Unlike in the pandemic sample, experience sampling reports were additionally collected during the day with a text message prompt three times per day at random times. All the questionnaires, and the dream, mind-wandering, and experience sampling reports were submitted via the same internet-based survey tool as in the pandemic sample.

Only data from the participants who provided informed consent, filled in the well-being survey, reported at least 5 dreams, and completed at least 5 mind-wandering tasks, were included in the current study ($N = 14$). The participants reported on average 11.86 dreams ($SD = 5.48$, range = 5–27), and altogether 166 dreams during the two-week study period.

2.3. Measures

2.3.1. Sleep quality and well-being

Sleep quality was measured in the pandemic sample with a question "How often have you experienced problems falling or staying asleep or sleeping too much in the last two weeks?" with response options on Likert-scale from 0 (not at all) to 3 (almost every day). The mean in the pandemic sample was 0.89 (between "not at all" and "a few days" during the past two weeks) with standard deviation 0.94. The most common responses were "not at all" (41.2 %) and "a few days" (35.3 %) while only 8.2 % reported sleep symptoms "almost every day". In the pre-pandemic sample, participants were specifically selected based on good sleep quality as measured by PSQI. Given majority of respondents in the pandemic sample reported no or only minor sleep problems, we can assume that also the pandemic sample consisted of individuals with relatively good sleep quality. To control whether sleep quality within the pandemic sample affected the results on threatening dream content, we run the same statistical tests with and without the worst sleepers who had responded having problems falling or staying asleep "almost every day" during the past two weeks ($n = 7$). Removing the worst sleepers did not affect the results, and thus we decided to include them in the final sample for more statistical power.

Well-being was measured with the Satisfaction with Life Scale (Diener et al., 1985), the Brunnsviken Brief Quality of Life Scale (Lindner et al., 2016) and the Positive and Negative Affect Schedule (Watson et al., 1988) where the participants were asked to evaluate affective states during the past two weeks. The pandemic and the pre-pandemic samples were compared with two-sample-t-tests. The pandemic sample scored lower ($M = 24.80$, $SD = 5.54$) than the pre-pandemic sample ($M = 29.21$, $SD = 2.19$) on the Satisfaction with Life Scale ($t(97) = 5.26$, $p < .001$, $d = 0.85$). However, both groups fall into the scoring range of "satisfied" according to the Satisfaction with Life Scale interpretation instructions (Diener et al., 1985). The pandemic sample ($M = 65.79$, $SD = 17.21$) did not differ from the pre-pandemic sample ($M = 68.71$, $SD = 12.29$) on the Brunnsviken Brief Quality of Life Scale ($t(97) = 0.77$, $p = .447$, $d = 0.18$), and in both samples the score is slightly higher than in the normative non-clinical psychology undergraduate student sample (Lindner et al., 2016). The pandemic sample ($M = 32.27$, $SD = 7.43$) and the pre-pandemic sample ($M = 34.07$, $SD = 3.56$) did not significantly differ in positive affect during the past two weeks as measured with PANAS ($t(97) = 1.44$, $p = .158$, $d = 0.26$). The pandemic sample ($M = 23.20$, $SD = 7.44$) and the pre-pandemic sample ($M = 19.71$, $SD = 6.79$) did not also significantly differ in negative affect during the past two weeks as measured with PANAS ($t(97) = -1.76$, $p = .095$, $d = 0.47$). Depressive symptoms were assessed in the pandemic sample with the Patient Health Questionnaire-9 (Kroenke et al, 2001) showing mild depressive symptoms ($M = 5.71$, $SD = 4.91$). Depressive symptoms were measured in the pre-pandemic sample with Beck Depression Inventory-II (Beck et al., 1996) showing none to mild depressive symptoms ($M = 4.36$, $SD = 4.22$).

2.3.2. The number of threatening events, the number of threats related to diseases, illness, or medical problems, and the number of severe threats in pre-pandemic vs. pandemic dreams

The pandemic and pre-pandemic dream reports were randomized and thus it was unknown to the raters whether a dream belonged to the pre-pandemic or pandemic sample and which dreams belonged to the same participant. All the reports were analyzed with a modified version of the Dream Threat Scale (Revonsuo & Valli, 2000), a content analysis method developed for identifying and categorizing threatening events in dream reports. The analysis was conducted in two stages: In the first stage the raters identified all the threatening events in the dream reports and in the second stage the raters categorised the threats in more detail based on the description of the event. In the current study, both stages were conducted by three independent raters. All the threats that were identified by at least two of the raters were included in the second stage. The utilized categories in the second stage included: the Nature of the Threatening Event, the Target of the Threat, the Severity of the Threatening Event for the Self, the Possibility of Actively Participating and Reacting to the Threat, the Participation of the Dream Self in the Event, the Nature of the Reaction of the Self to the Threatening Event, the Resolution of the Threat, and the Realistic Nature of the Threatening Event. All the raters were blind to each other's ratings.

Given that the hypotheses focused on whether the number of threatening events, threatening events related to diseases, illness, or medical problems, or severity of threatening events differs between the pandemic and pre-pandemic samples, the absolute number of threats and the categories the Nature of the Threatening Event and Severity of the Threatening Event for the Self were subjected to statistical analyses. In the category the Nature of the Threatening Event, those categorisations that were assigned identically by at least two of the three independent raters were accepted to the statistical analyses. In the Severity of the Threatening Event for the Self category, all threats that were classified as life-threatening, or socially, psychologically, or financially severe, or physically severe were considered as severe threats as opposed to minor threats. If at least two out of the three raters had rated the threat as severe it was included in the analyses even if the raters had not agreed on the specific subcategory. The descriptive results regarding the remaining categories (the Target of the Threat, the Possibility of Actively Participating and Reacting to the Threat, the Participation of the Dream Self in the Event, the Nature of the Reaction of the Self to the Threatening Event, the Resolution of the Threat, and the Realistic Nature of the Threatening Event) are reported for both samples in the Supplement (Tables S1-S6).

2.3.3. Classification of pandemic sample dreams with and without direct references to the pandemic

We classified the dreams in the pandemic sample further into two categories: dreams with content that referred directly to the pandemic and dreams without pandemic content. This categorization was used because we assumed that in the pandemic sample especially those dreams that include direct references to the pandemic would contain a higher number of threats, and more threats related to diseases, illness, or medical problems, and more severe threats. A dream with pandemic content was defined as a report which includes themes, terms and/or events that are specific to the experiences that occurred during the coronavirus pandemic. Binary confirmation was carried out by two judges, and disagreements were resolved via discussion. Ambiguous dreams were discarded from analyses.

2.4. Statistical analyses

The data were analyzed with generalized linear mixed-effect models using the glmmTMB package (Brooks et al., 2022) in R statistical software (Version 4.2.2; R Core Team, 2022). Due to the inflation of zero values in the data (45.8 % of the dreams did not contain threats), *glmmTMB* was chosen over the more widely used *lme4* (Bates, Mächler, Bolker, & Walker, 2015) as it can take the zero-inflation into account. Separate models were built to compare whether 1) the number of threatening events, 2) the number of dreams with a threat related to diseases, illness, or medical problems, and 3) the probability of a threat to be severe differed between the pandemic and pre-pandemic samples. The pandemic/pre-pandemic variable was fitted into the models 1–3 as treatment coded fixed effect with pre-pandemic situation as the baseline (Schad et al., 2020). Separate models were built to compare whether 4) the number of threatening events, 5) the number of dreams with a threat related to diseases, illness, or medical problems, and 6) the probability of a threat to be severe differed between dreams in the pandemic sample that included vs. did not include direct references to the pandemic. Includes / does not include references to the pandemic variable was fitted into the models 4–6 as sum coded fixed effect. Age and gender were controlled for in the analyses by fitting them into the models as fixed effects variables. Age was fitted as a continuous variable, and gender as a deviation coded variable. Participants were entered to the models as random intercepts (Baayen et al., 2008). The maximal random structure was fitted to the model (Barr et al., 2013). If the model failed to converge with the full random structure, the random structure of the model was trimmed top-down, starting with correlations between factors (see Brauer & Curtin, 2018). The exact degrees of freedom are difficult to determine for z-statistics estimated by generalized linear mixed-effect models, leading to problems in determining exact p-values (Baayen et al., 2008). Statistical significance at the 0.05 level is indicated by the values of $|z| > 1.96$. All the models were tested for zero-inflation and overdispersion using the DHARMa package (Hartig, 2022). For the zero-inflated models, the predictors to be fitted in the zero-inflation part of the models were determined by comparing models with each other using *bbmle* package (Bolker, 2022). We started with a model with only an intercept, followed by a model in which the fixed effect variable in the model were fitted. The model providing the best fit to the data (lowest AIC value) was selected. If the model also showed overdispersion, it was refitted using zero-truncated Poisson distribution (see e.g., Valero et al., 2010). All the final models are reported in the Supplementary tables (Tables S7-S12).

3. Results

3.1. The number of threatening events

In the pandemic sample, there were a total of 1001 threats in 1132 dreams ($M = 0.88$ threats per dream, $SD = 1.06$). In the pre-pandemic sample, there were total of 121 threats in 166 dreams ($M = 0.73$ threats per dream, $SD = 0.96$). In the pandemic sample, 508 (44.9 %) dreams and in the pre-pandemic sample 87 (52.4 %) dreams did not contain any threats. Although the difference in the mean number of threats was in the predicted direction (pandemic 0.88 vs. pre-pandemic 0.73), the model for the *number of threatening events* did not reveal a significant difference between the pandemic and pre-pandemic samples, $\beta = 0.21$, 95 % CI [-0.19, 0.60], $z = 1.03$.

3.2. The number of threats related to diseases, illness, or medical problems

The frequencies for the Nature of the Threatening Event category are shown in Table 1. In the pandemic sample, there were 124 (15.1 %) threats related to diseases, illness, or medical problems, and in the pre-pandemic sample, there were 7 (7.3 %) threats related to diseases, illness, or medical problems. Although the difference was in the predicted direction and the relative frequency more than two times higher in the pandemic vs. pre-pandemic dreams (15.1 % vs. 7.3 %), the model for the *number of dreams with a threat related to diseases, illness or medical problems* did not reveal a significant difference between the pandemic and pre-pandemic samples, $\beta = 0.64$, 95 % CI [-0.28, 1.55], $z = 1.36$.

3.3. The probability of severe threats

The frequencies for the subcategories of the Severity of the Threat scale are shown in Table 2. In the analysis, life-threatening, and socially, psychologically or financially severe, and physically severe threats were combined to severe threats and compared against minor threats. In the pandemic sample, at least two of the three raters coded 451 (45.1 %) threats as severe and 550 (55.0 %) as minor, and in the pre-pandemic sample 57 (47.1 %) threats as severe and 64 (52.9 %) as minor. In the pandemic sample, there were 786 (69.4 %) dreams, and in the pre-pandemic sample 123 (74.1 %) dreams without any severe threats. The model for the *probability of threat being severe* did not reveal a significant difference between the pandemic and pre-pandemic samples, $\beta = -0.27$, 95 % CI [−0.90, 0.36], $z = -0.83$.

3.4. The number of threatening events in the pandemic sample dreams with and without direct references to the pandemic

In the 1132 pandemic sample dreams, 1081 dreams were detailed enough for coding of pandemic content, and 51 were discarded due to ambiguity. Only 125 (11.6 %) of pandemic sample dreams had direct references to the pandemic, with 146 threats in these dreams ($M = 1.17$ threats per dream, $SD = 1.07$). Of the dreams with references to the pandemic, 35 (28.0 %) dreams did not contain any threats. In the pandemic sample dreams without direct references to the pandemic, there were 846 threats in 956 dreams ($M = 0.88$ threats per dream, $SD = 1.06$) and 429 (44.9 %) dreams did not contain any threats. The model for the *number of threatening events* in the pandemic sample dreams revealed a significant difference between dreams with and without pandemic content, $\beta = 0.29$, 95 % CI [0.10, 0.48], $z = 3.02$. This effect indicates that the pandemic sample dreams with direct references to the pandemic had more threatening events than pandemic sample dreams without pandemic content.

3.5. The number of threats related to diseases, illness, or medical problems in the pandemic sample dreams with and without direct references to the pandemic

The frequencies for the Nature of the Threatening Event between dreams with and without direct references to the pandemic are shown in Table 3. In the dreams with pandemic content there were 60 (48.4 %) threats related to diseases, illness, or medical problems while in the dreams without direct references to the pandemic only 62 (9.0 %) threats were related to diseases, illness, or medical problems. The model for the *number of dreams with a threat related to diseases, illness, or medical problems* revealed a significant difference

Table 1
Frequencies for the nature of the threatening event.

	Pre-pandemic sample		Pandemic sample	
	N (96)	%	*N* (823)	%
Escapes and pursuits	6	6.3	36	4.4
Accidents and misfortunes	19	19.8	131	16.0
Failures	28	29.2	218	26.5
Catastrophes	3	3.1	23	2.8
Diseases, illness, or medical problems	7	7.3	124	15.1
Aggression and violence	24	25.0	219	26.6
The threatening event cannot be classified	9	9.4	72	8.7

Note. Due to disagreements between raters 25 threats in the pre-pandemic sample and 178 threats in the pandemic sample were excluded.

Table 2
Frequencies for the Severity of the Threat.

	Pre-pandemic sample		Pandemic sample	
	N (105)	%	*N* (929)	%
Life-threatening	15	14.3	96	10.3
Socially, psychologically, or financially severe	20	19.0	173	18.6
Physically severe	6	5.7	110	11.8
Minor	64	61.0	550	59.2

Note. Due to disagreement between raters 16 threats in the pre-pandemic sample and 72 threats in the pandemic sample were excluded in the detailed Severity of threat categorization. All these excluded threats were included in the binary analysis.

Table 3
Frequencies for the Nature of The Threatening Event between dreams without and with pandemic content in the pandemic sample.

	Pandemic sample dreams without references to the pandemic		Pandemic sample dreams with references to the pandemic	
	N (690)	%	*N* (124)	%
Escapes and pursuits	34	4.9	2	1.6
Accidents and misfortunes	118	17.1	10	8.1
Failures	191	27.7	27	21.8
Catastrophes	20	2.9	3	2.4
Diseases, illness, or medical problems	62	9.0	60	48.4
Aggression and violence	199	28.8	16	12.9
The threatening event cannot be classified	66	9.6	6	4.8

Note. Due to disagreements between raters 156 threats in the pandemic sample without references to the pandemic, and 22 threats in the pandemic sample with references to the pandemic were excluded.

in the pandemic sample between dreams with and without pandemic content, $\beta = 2.72$, 95 % CI [2.06, 3.38], $z = 8.06$. This effect indicates that dreams with direct references to the pandemic had more threats related to diseases, illness, or medical problems than dreams without pandemic content.

3.6. The probability of severe threats in the pandemic sample dreams with and without direct references to the pandemic

The frequencies for the Severity of the Threat between dreams with and without pandemic content in the pandemic sample are shown in Table 4. In dreams with direct references to the pandemic, at least two out of the three raters coded 85 (58.2 %) threats as severe and 61 (41.8 %) as minor, and in dreams without pandemic content 358 (42.3 %) threats as severe and 488 (57.7 %) as minor. The model for the *probability of threat being severe* revealed no significant difference between dreams with and without direct references to the pandemic, $\beta = 0.40$, 95 % CI [-0.09, 0.90], $z = 1.60$. However, zero-inflation model revealed a main effect of pandemic content, $\beta = -0.54$, 95 % CI [-1.02, -0.07], $z = -2.27$. This indicates that dreams with direct references to the pandemic had lower probability of containing exactly zero severe threats than dreams without pandemic content.

4. Discussion

The aim of this study was to examine whether, as predicted by the threat simulation theory, the COVID-19 pandemic increased the number of threatening events in dreams, the number of threats related to diseases, illness, or medical problems in dreams, or rendered the threatening events in dreams more severe compared to dreams reported before the pandemic (H1-H3). Contrary to our hypotheses H1-H3, the pre-pandemic and pandemic samples did not differ significantly regarding the number, nature, or severity of threats. This is somewhat surprising also considering that the pandemic sample participants reported higher levels of mild depressive symptoms, and

Table 4
Frequencies for the Severity of the Threat Scale between dreams without and with references to the pandemic in the pandemic sample.

	Pandemic sample dreams without references to the pandemic		Pandemic sample dreams with references to the pandemic	
	N (789)	%	*N* (134)	%
Life-threatening	86	10.9	10	7.5
Socially, psychologically, or financially severe	140	17.7	28	20.9
Physically severe	75	9.5	35	26.1
Minor	488	61.9	61	45.5

Note. Due to disagreements between raters 57 threats in the dreams without references to the pandemic, and 12 threats in the dreams with references to the pandemic were excluded in the detailed Severity of the threat categorization. All these excluded threats were included in the binary analysis.

the pre-pandemic sample participants had been screened for excellent sleep quality. Depressive symptoms and poorer sleep quality, especially insomnia symptoms, have been associated with nightmares (e.g., Sandman et al., 2015) which are paradigm cases of threat simulation dreams. However, the sleep quality in the pandemic sample was also generally good and the samples did not differ in the satisfaction or quality of life. In addition, the samples did not differ in positive or negative emotions experienced during the past two weeks. In general, the samples were quite similar considering sleep quality and well-being.

In accordance with our results, Koppehele-Gossel et al. (2023) found no differences in threat-related words (such as threat, fear, accident, weapon, war, pain, crying and death) between German pre-pandemic and pandemic dream samples. Wang et al. (2021) have reported an opposing finding in a Chinese sample, albeit in a much smaller sample of dreams which were collected with the most recent dream method. They found an increase in the general threat content in dreams collected during vs. before the pandemic in China but no increase in the number of disease-related threats. Yet, our pandemic sample had more than double the percentage of threats related to diseases, illness, or medical problems than the pre-pandemic sample (15.1 % and 7.3 % of all threats, respectively), even if the difference was not statistically significant. Interestingly, in the Chinese sample of pandemic dreams collected by Wang et al. (2021) with the most recent dream method, 15.4 % contained disease-related threats, a proportion directly comparable to our finding.

We also hypothesized that dreams with direct references to the pandemic would have higher number of threatening events, more threats related to diseases, illness, or medical problems, and threats would be more severe compared to dreams without direct references to the pandemic (H4-H6). These predictions were confirmed. Regardless, in our large sample of prospectively collected dreams, only 11.6 % of all dreams included direct references to the pandemic. A similar rate of incorporation during the first (11 %) and the second wave of the pandemic (8 %) has been reported by Koppehele-Gossel et al. (2023) with a dream diary method, and during the first wave of the pandemic (20 %) by Iorio et al (2020) with the most recent dream method. Domhoff (2022) has found an even smaller percentage of dreams (4.7 %-5.2 %) to include pandemic-related content, in a sample of almost four hundred dreams reported by five young American female long-term dream diarists whose waking lives did not seem to be heavily affected by the pandemic. He, however, also reported one case where the person's waking concerns were focused on the pandemic and her dreams were much more heavily laden with pandemic content. In an Italian population, Scarpelli et al. (2022b) found pandemic themes to rank as tenth in a sample of dreams collected during lockdown, and in post-lockdown dreams, the pandemic themes had fallen off the top ten. Thus, although the pandemic has clearly been incorporated into dreams, the incorporation rate in systematically collected samples is not as high as could have been assumed based on survey studies.

Yes, as predicted, this small number of dreams with direct references to the pandemic included more threatening events, more threats related to diseases, illness, or medical problems, and more severe threats than dreams during the pandemic without pandemic content. Although not all dreams with pandemic content are threatening or distressing, as evidenced by the current study and those by Domhoff (2022), Koppehele-Gossel et al. (2023) and Wang et al. (2021), these dreams included more threat simulations than dreams without references to the pandemic. Disease-related threats were five times more prevalent in dreams that represented pandemic content, and the threats were generally more severe, especially physically more severe. The increase specifically in this subcategory is explained by our coding rules: unless severity was otherwise specified in the dream report, coronavirus related threats were classified as physically severe. Thus, it seems that even though dreams with direct references to the pandemic are not among the most frequent types of dreams and that the overall threat content did not drastically change after the onset of the pandemic in our Finnish sample, clearly the novel world-wide threat did affect a small proportion of dreams more profoundly. These findings can be interpreted as evidence of some level of activation of the threat simulation system in response to an unforeseen and unpredictable novel threat that was pervasive in the society, with massive media coverage and notable effects on people's occupational and private lives.

The pandemic sample of this study was overwhelmingly female (4 men, 78 female) and previous studies have shown that the pandemic affected women's dreams more than men's dreams (Barrett, 2020; Kilius et al., 2021; Parrello et al., 2021). In light of this unbalanced gender distribution, we cannot draw systematic conclusions about how men's dreams were affected by the pandemic. However, accounting for gender (or age) did not affect the results, and had we had a more balanced gender distribution our results would have likely been even more meager.

The threat simulation theory does not make direct and clear predictions about the expected incorporation of the pandemic into dreams, and thus, our study cannot be conceived as a strong test of the theory. Overall, as suggested by the findings of the present study and that of Koppehele-Gossel et al. (2023), it seems that the pandemic did not activate the threat simulation mechanism in the general population on a larger scale. Rather, threatening dream content seems to stay relatively stable across time and context, and while specific types of new threats are incorporated to a minority of dreams, the overall threat frequency or content are not significantly affected on a population level. According to the TST, threatening events are regular and frequent in our dreams, and our results are compatible with this claim.

Notably, other dream function theories also predict an increase of pandemic-related content in dreams. For example, the continuity hypothesis and the neurocognitive theory would state that daily experiences and activities, and especially current concerns, are easily incorporated into dreams (Domhoff, 2022; Schredl & Hofmann, 2003). Similarly, emotion processing and regulation theories predict that emotional stimuli are incorporated into dreams, for the purpose of diminishing the emotional impact of the memory trace (Cartwright, 2010; Hartmann, 1996; Levin & Nielsen, 2009, 2007; Malinowski & Horton, 2015; Nielsen & Levin, 2007). All these theories thus predict that the pandemic would have an effect on dream content but offer different explanations for the incorporation. Therefore, our study is not suitable to determine which of the theories would gain more or less support by our findings.

To summarize, it seems that the effects of the pandemic on dream content were not as shocking as first reported in media or as pervasive as reported in early survey studies. Our results, in fact, contradict many of the previous findings reported on the effect of the COVID-19 pandemic on dreams, especially those based on surveys or the most recent dream method. Several survey studies have concluded that dreams during the pandemic were more negatively toned (Barrett, 2020; Conte et al., 2022; Giovanardi et al., 2021;

Gorgoni et al., 2021; Meaklim et al., 2023; Parrello et al., 2021; Scarpelli et al., 2021, 2022a; Schredl & Bulkeley, 2020; Simões et al., 2022; Solomonova et al., 2021), had more threatening events (Wang et al., 2021) and there were more nightmares (Pesonen et al., 2020). We found no such overall effect and conclude that only a minority of dreams in our sample, those with direct references to the pandemic, were affected. Notably, these types of disease-laden pandemic dreams might have also been the dreams that people easily came to think of when they responded to retrospective surveys about dreams during the pandemic. This would partially explain the differences between findings based on surveys vs. systematic diaries.

In addition, dream samples and surveys collected in different countries might not be directly comparable, even if the same or a similar method was used. The pandemic affected different countries to different extents, and restrictive measures varied between nations. Consequently, dreams might have been more or less affected in different countries, depending on how drastic the effects were on peoples' lives, how burdened the health care systems were or how isolated people became due to restrictions. For example, many of the survey studies were conducted in Italy where the numbers of COVID-19 cases, hospitalizations, and deaths were much higher than in Finland. In addition, the population density is higher, and the culture in Italy is more communal than in Finland. In Italy there were more restrictions due to the pandemic and the authorities enforced those restrictions more strictly than in Finland. It is possible that in Italy there was more COVID-19 worry than in Finland and the results from the Italian (and other) survey studies vs. our diary study reflect the difference between Finnish and other populations. This explanation might also apply to the results in the Chinese pandemic dream samples and why they were different from the Finnish sample. To determine the effects of the chosen sample and methodology on the results of COVID-19 pandemic's effect on dream content we would, in addition to dream diary and survey data collected with similar methods before and during the pandemic, also need a measurement of subjective COVID-19 worry in each country.

Yet, the discrepancy in results between surveys and diary studies is unlikely to be fully explained by sample-specific characteristics. Pesonen et al. (2020) collected a sample of dreams from the Finnish population using a retrospective survey at the same time as we collected our sample. Their results match the studies utilizing surveys and the most recent dream method in other countries but contradict with the results from this study. Thus, it is not likely that the discrepancy in results between the survey studies and diary studies, such as ours, are entirely due to differences in study populations but rather at least partly related to differences in sampling methods. While there could be other reasons for the discrepancy between findings in survey vs. dream diary studies, one central explanatory factor seems to be the chosen methodology. Retrospective surveys tend to tap into recently recalled, emotionally intense and negative dreams. Many surveys even requested participants to report dreams that they believed were induced by or related to the pandemic, thus necessarily focusing on emotionally negative or nightmarish dreams. Because dreams with pandemic content were more threatening, as demonstrated in this study, and these threats focused on representing diseases and the virus, they were more easily recalled than other, more mundane or positive dreams.

Notably, our memory for affective experiences is biased both during waking and dreaming. When people are asked to report a recent waking-life emotional experience, they tend to focus on negative rather than positive events and underestimate the frequency of their positive affect (Thomas & Diener, 1990). We tend to retrospectively evaluate our affective experiences as more pleasant or unpleasant compared to how we evaluate the experience when we are having it, and this memory-experience gap is larger for unpleasant emotions (Miron-Shatz et al., 2009). In addition, the longer the delay between the dream experience and the reporting of the dream or its features, the stronger the memory bias (Sikka, 2019). Thus, the retrospective survey data are likely biased towards representing recollections of negative dream content, instead of being representative of all dreams. Consequently, retrospective questionnaires do not necessarily provide accurate information about people's dream recall or content and tend to measure aspects of the Remembering self rather than the Experiencing self (Kahneman, 2011). Further, because retrospective estimates are influenced by our waking beliefs or knowledge about ourselves (the Believing self), retrospective questionnaires also seem to measure people's perception of their dreams or themselves as dreamers rather than the accurate recall of dream experiences (Sikka, 2020). Contrary to questionnaire studies, we asked participants to keep a prospective dream diary for two weeks and to report all the dreams they had. By instructing the participants to write down their dreams immediately after waking up we could minimize the temporal distance between the actual dream experience and the reporting, making the reports less prone to memory bias. One possible downside to prospective dream diary studies such as ours is that there could be a selection bias in people who are willing to complete this kind of a high effort dream diary without compensation. These people tend to be more open to new experiences and have higher dream recall (Schredl et al., 2003).

To conclude, while we found no statistically significant differences in the overall threat content of dreams collected before and during the most acute stage of the pandemic, approximately one tenth of the systematically prospectively collected dreams during the pandemic represented pandemic-related content. These dreams were also more often threatening, with the threats focused on diseases and illnesses. This potentially explains why survey study findings have emphasized the highly negative effect of the pandemic on dreaming. With systematically collected dream diaries, the differences between dreams before and during the pandemic appear much more subtle and meager. Thus, due to the memory biases our study questions the rationale to use retrospective questionnaires when studying dream content: Such measures tell us more about how our dreams are represented in long-term memory and in the beliefs of ordinary people who do not keep any records of their dreams, rather than representing different kinds of dream contents and their actual frequencies of occurrence in dreams. To ensure valid data about dream contents, full dream reports should be systematically collected from people who record all their dreams without intervening delays or memory biases. To really determine whether the COVID-19 pandemic made dreams more negative, nightmarish, or increased the number of threatening events in dreams, more high-quality research utilizing prospective dream diaries with a proper baseline control sample would be needed.

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Ville Loukola: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. **Jarno Tuominen:** Data curation, Investigation, Writing – review & editing. **Santeri Kirsilä:** Formal analysis, Writing – review & editing. **Annimaaria Kyyhkynen:** Formal analysis, Writing – review & editing. **Maron Lahdenperä:** Formal analysis, Writing – review & editing. **Lilja Parkkali:** Formal analysis, Writing – review & editing. **Emilia Ranta:** Formal analysis, Writing – review & editing. **Eveliina Malinen:** Formal analysis, Writing – review & editing. **Sanni Vanhanen:** Formal analysis, Writing – review & editing. **Katariina Välimaa:** Formal analysis, Writing – review & editing. **Henri Olkoniemi:** Formal analysis, Methodology, Supervision, Writing – review & editing. **Antti Revonsuo:** Conceptualization, Methodology, Project administration, Supervision, Writing – review & editing. **Katja Valli:** Conceptualization, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.concog.2024.103651.

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