



Research paper

The association between intolerance of uncertainty and depressive symptoms during COVID-19 in New York, USA

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ABSTRACT

Background: Coronavirus Disease 2019 (COVID-19), a highly contagious respiratory illnesses, has globally impacted mental health. This study aims to investigate the association between intolerance of uncertainty and depressive symptoms during the pandemic in New York, USA, considering COVID-19-related worries as modifiers and mediators.

Method: 1227 participants from three ongoing cohort studies, originally centered on trauma-exposed children and adolescents, provided data via questionnaires and telephone interviews across three waves. We used multivariable logistic and linear regression models to investigate the intolerance of uncertainty-depressive symptoms relationship, while adjusting for potential confounders and assessing the modification and mediation effects of Covid-19 related worries.

Results: Depressive symptoms prevalence was 18 %, 12 %, and 9 % at waves 0, 1, and 2 respectively. Strong positive associations were observed between intolerance of uncertainty above the median and depressive symptoms which remained significant after adjusting for potential confounders. Odds ratios were 2.14 (95 % CI: 1.54–2.99) and 4.50 (95 % CI: 2.67–7.93) for intolerance of uncertainty-depressive symptoms association at wave 0 and 1 respectively, and 3.22 (95 % CI: 1.68–6.63) for intolerance of uncertainty at wave 1 and depressive symptoms at wave 2. There was evidence of partial mediation by worries (12–37 %), but no evidence of a moderating effect.

Limitation: It includes study's methodology, including self-report measures, remote data collection, and uncontrolled variables like anxiety and COVID-19 perspectives.

Conclusion: The findings emphasize the importance of evidence-based strategies for tackling intolerance of uncertainty during pandemics, particularly in managing long COVID. Collaborative efforts between policymakers and clinicians are essential in this endeavor.

1. Introduction

Coronavirus Disease 2019 (COVID-19), an extremely infectious respiratory illness caused by the SARS-CoV-2 virus, was first detected in Wuhan, China, in December 2019. This disease rapidly evolved into a global health emergency due to its rapid spread across the world (Wu et al., 2020). In order to mitigate transmission of the virus, governments worldwide implemented strict measures, including implementation of social isolation, quarantining, and lockdowns. Although these strategies proved effective in curbing the spread of the virus, they also had some

influences on mental well-being (Sojli et al., 2021). SARS-CoV-2 is known to affect the central nervous system, and can cause psychiatric and cognitive symptoms including depression and anxiety, as well as confusion and memory loss, which may endure for an extended period (De Berardis, 2022; Kumar et al., 2021). Several investigations into the mental health effects of the pandemic, such as a meta-analysis by Salari et al., have revealed widespread occurrences of anxiety and depressive symptoms globally (Salari et al., 2020). Among the factors leading to depression, intolerance of uncertainty (IU) has emerged as significant (Shu et al., 2022), a trait that is prevalent during the COVID-19

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pandemic due to its unprecedented and novel nature. This situation can lead to a heightened sense of uncertainty, fueled by the unpredictability of future outcomes (Del-Valle et al., 2022).

Intolerance of uncertainty is a cognitive bias characterized by difficulties in handling ambiguous situations, which affects thought processes, emotions, and behaviors. Individuals with IU find uncertainty distressing and often seek to avoid it, which can impair their ability to function effectively in situations with uncertain outcomes. IU is considered a key indicator of a propensity to worry, prevalent in both clinical and nonclinical groups (Dugas and Ladouceur, 2000). It involves a tendency to react negatively to uncertain situations irrespective of their likelihood, leading to poor emotional regulation, inadequate coping strategies, reduced attentional focus, and a range of behavioral, cognitive, and emotional disorders like anxiety and depression (Dugas et al., 2001; Shu et al., 2022).

Depression presents in various dimensions, such as cognitive, affective, and somatic symptoms. A notable aspect related to depression is intolerance of uncertainty, which includes inhibitory IU—fear of unpredictable future events—and prospective IU—avoidance behavior due to uncertain outcomes. Saulnier et al. (2019) established that general IU is associated with both cognitive and affective symptoms of depression, with a significant connection specifically between inhibitory IU and the cognitive aspects. This suggests an important interaction between the inhibitory component of IU and cognitive symptoms in depression (Saulnier et al., 2019). The presence of uncertainty hampers effective anticipation of future events, thus impacting mental health (Grube and Nitschke, 2013). Although IU is connected strongly to Generalized Anxiety Disorder (GAD), newer theoretical models propose that this intolerance could also pave the way for Major Depressive Disorder (MDD) (Gentes and Ruscio, 2011). Hamama-Raz et al. conducted a study involving 1030 participants using data from the Israeli Ipanel company's COVID-19 mental health survey. Their findings showed a clear link between intolerance of uncertainty and depression during the COVID-19 pandemic (Hamama-Raz et al., 2021), following mechanisms similar to those observed in GAD. It is theorized that people suffering from GAD use worrying as a tool to manage their feelings of uncertainty and anxiousness about what the future holds, paradoxically leading to heightened anxiety and potentially depressive symptoms (Dar et al., 2017; Newman and Llera, 2011). Boswell et al. highlighted the significant role of intolerance of uncertainty in the treatment of various psychological disorders. It reveals that changes in IU levels are closely linked to the improvement of symptoms across multiple diagnoses, not just in anxiety disorders but also in depressive disorders (Boswell et al., 2013).

The relationship between intolerance of uncertainty and depressive symptoms is complex, influenced by various variables, including worries (Jensen et al., 2016). Worries involve a series of uncontrollable negative thoughts and images that intensify anxiety by amplifying the perceived likelihood and severity of threats (Borkovec et al., 1983). Within the context of intolerance of uncertainty, individuals with high IU are more prone to excessive worrying due to their discomfort with ambiguity. This persistent focus on negative future events can exacerbate anxiety, contributing to depressive symptoms (Dar et al., 2017). The COVID-19 pandemic has given rise to a wide range of worries among individuals, including financial, health, and social concerns. Financial worries have become a significant source of distress due to job losses and reduced income. For example, in February 2020, the United States had a record-low unemployment rate of 3.5 %. However, the COVID-19 pandemic caused a sudden economic disruption, resulting in a staggering surge in unemployment. By April 2020, the unemployment rate reached 14.7 %, with a loss of 20.5 million jobs (Wilensky, 2021). Health worries have also contributed to substantial anxiety and depressive symptoms, stemming from the unpredictable nature of the virus and fears of infection and loss of loved ones (Del-Valle et al., 2022; Fiorillo and Gorwood, 2020). In 2020, the American Psychiatric Association (APA) reported that nearly half of Americans (48 %) expressed concern about

contracting COVID-19, while 62 % expressed worries for their family members or loved ones (Canady, 2020). Additionally, social worries have arisen as a consequence of gathering restrictions, social distancing mandates, and limited opportunities for socialization leading to feelings of isolation and loneliness (Hwang et al., 2020). Previous research has examined the impact of worries on the association between IU and depressive symptoms, exploring their roles as mediators and moderators (Dar et al., 2017; Dugas et al., 2004). Building upon this line of inquiry, Dar et al. assessed the mediation and moderation role of worries on the association between IU and depressive symptoms. They found that worry significantly predicted depressive and anxiety symptoms, and a high level of worry increased the association between IU and depressive symptoms and anxiety. Furthermore, they found that worry acts as a mechanism and/or moderator in the relationship between IU and depressive symptoms (Dar et al., 2017).

To comprehensively understand the association between intolerance of uncertainty and depressive symptoms, as well as the effects of covariates, it was crucial to conduct research on a significantly affected, large and diverse population such as that found in metropolitan New York City, USA. New York City's multicultural population, coupled with its high COVID-19 mortality rates (Thompson et al., 2020), provides researchers with a valuable resource for examining the association between intolerance of uncertainty and depressive symptoms, as well as the effects of other covariates in similar contexts. Based on previous research demonstrating the influence of worries as effect modifiers and mediators, it is hypothesized that increased levels of worries will amplify the relationship between IU and depressive symptoms. This hypothesis is rooted in the understanding that worries may exacerbate the negative impact of uncertainty on mental health. Importantly, while numerous studies have investigated the association between IU and depressive symptoms during COVID-19, to our knowledge, none have explored the role of COVID-19 related worries as potential moderators and mediators in this relationship. Therefore, the aim of this study is to deepen our understanding of the complex association between intolerance of uncertainty and depressive symptoms within the context of the COVID-19 pandemic. By specifically examining the dual role of COVID-19-related worries as moderators and mediators, the study aims to elucidate the underlying mechanisms that govern this relationship. The insights gained from this research will empower us to better prepare for future pandemics, ensuring the required knowledge to develop comprehensive and effective strategies for mental health support.

2. Methods

This study employed data from a survey examining the mental health effects of the COVID-19 pandemic on a random selection of 1227 participants from three existing cohorts. The three ongoing cohort studies were conducted by the Global Psychiatric Epidemiology Group (GPEG) in New York, USA. Two of these studies specifically focused on children who were either directly or indirectly exposed to the September 11, 2001 (9/11) terrorist attack on the World Trade Center (WTC) in New York City (NYC), USA. The third study examined how children's mental health is influenced by parental involvement in the criminal justice system. Each of the studies enrolled both youth (now young adults) and parent participants. Data collection for the current study involved conducting telephone surveys in three waves: March to August 2020 (wave 0), September 2020 to February 2021 (wave 1), and March to August 2021 (wave 2).

The participants for wave 0 were selected by randomly ordering a list of participants from the three cohorts, and then contacting participants in order until the target sample size ($n \sim 1200$) was attained. The refusal rate among contacted participants for wave 0 was 17 %. Waves 1 and 2 followed the wave 0 participants, with 76 % and 67 % participation rates, respectively. The questionnaire was developed by the GPEG research group, addressing mental health and the participants' experiences with COVID-19. All covariates were self-reported by the

participants. Those participants with missing information on exposures and outcomes of interest for the current investigation were excluded from the analyses below. The final sample sizes for waves 0, 1, and 2, with complete information on both the intolerance of uncertainty and depressive symptoms, were 1213, 925, and 720, respectively. The survey was conducted with approval of the Institutional Review Board of the New York State Psychiatric Institute. Subsequently, the Regional Committee for Medical Research Ethics (REK) in Norway approved this study of secondary data analysis (Ref.nr. 2022/453416). The study was conducted in accordance with the principles of the Declaration of Helsinki, and all participants provided informed consent prior to participating. To safeguard participants' privacy and confidentiality, all personally identifiable information was removed from the data prior to receipt in Norway. A diagram illustrating the association between intolerance of uncertainty and depression, through the direct and indirect effects of worry in both cross-sectional and prospective relationships, was included in the supplemental material (see Supplemental Material, Graph 1). This study was conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines (see Supplemental Material, Table 4).

2.1. Measures

2.1.1. Depressive symptoms

It was evaluated at each of the three waves using the PHQ-8, an eight-item scale designed to assess depressive symptoms. Respondents rated each item on a scale ranging from 0 to 4, where 0 indicated "Not at all" and 4 represented "Nearly every day". The total scores were then categorized into two groups based on a cut-off point of 10 or higher, which has been validated for the PHQ-8. The PHQ-8 was selected as the preferred tool for measuring depressive symptoms in our study based on the research by Kroenke et al. Their study demonstrated the efficiency of the PHQ-8 for a large population dataset and validated a cut-off value of ≥ 10 as having high sensitivity and specificity for major depressive disorder. Participants with scores below 10 were classified as experiencing none to slight depressive symptoms, while those with scores equal to or above 10 were categorized as having moderate to severe depressive symptoms (Kroenke et al., 2009).

2.1.2. The intolerance of uncertainty

It was based on Buhr et al.'s study (2002), evaluating how much respondents were tolerant of uncertainty and distress as a result of uncertainty (Buhr and Dugas, 2002). This is a 27-item scale with a five-point Likert scale ranging from 1 = "not at all characteristics of me" to 5 = "entirely characteristic of me". These questionnaires were administered to participants at two points (waves 0 and 1). These scores were categorized as below and above the median of all responses, separately for waves 0 and 1 (34 and 31, respectively). To assess the robustness of our findings and conduct a sensitivity analysis, we additionally examined the data using the IUS as a continuous variable. Associations with the continuous IUS measure are presented in terms of the interquartile range (IQR) of IU. Cronbach's alpha for IUS at waves 0 and 1 were: wave 0 = 0.86, wave 1 = 0.89.

2.1.3. COVID-19-related worries

COVID-19-related financial, health and social activity worries were assessed using dichotomous questions asking whether the participant worried about specific items. The worries scores were grouped into two categories: below and above the median. The items were as follows:

- Finance related worries: personal finances, not being able to pay rent or mortgage, possible cuts to government assistance, not being able to afford health care, not being able to be tested for the Coronavirus, becoming homeless, not being able to pay bills, losing own health benefits, paying next month's rent/mortgage, losing job, never earn a decent salary after the Coronavirus, not being able to retire with a

pension, the current national economy, being unemployed, not being able to find a job, debt or loans, recovering financially from the pandemic, the local economy, surviving of small businesses, possible cuts to future or current pension, hunger in the community, being evicted from home (Scores were computed as the total number of items listed above which the respondent endorsed as worries, and the scores were dichotomized at the median values of 5 and 4 for waves 1 and 2, respectively).

- Health related worries: pet's health, worsening of the pandemic, personal health problems, possibility of contracting the Coronavirus (COVID-19), possibility of your child(ren) getting the Coronavirus, unknowingly spreading the Coronavirus, possibility of your grandparents contracting the Coronavirus, health problems of a family member, having a COVID-19 safe environment at work, accessing affordable tele-health services, neglect/abuse in nursing homes, flu season in fall and winter, possibility of your parents getting the Coronavirus, your baby's health, a second wave of the Coronavirus, how long this pandemic may last, inability to get a good night's sleep, losing childcare, emotional recovery from the pandemic (Scores were computed as the total number of items listed above which the respondent endorsed as worries, and the scores were dichotomized at the median values of 9 and 6 for waves 1 and 2, respectively).
- Social activities related worries: not being able to socialize, not being able to attend funeral/memorial services, schools reopening, backing youth to school, work/graduation, not being able to participate in family gatherings, not being able to attend religious services, not being able to celebrate holidays with friends and family, reduction of social services, closure of favorite restaurant(s), vacation plans during the next few months, not having normal life again (Scores were computed as the total number of items listed above which the respondent endorsed as worries, and the scores were dichotomized at the median values of 5 and 3 for waves 1 and 2, respectively).

2.1.4. Demographic characteristics

Gender, age, race and ethnicity, religion, marital status, job status, and income status; and COVID-19 exposure were based on participant self-report. The original cohort was also included as a covariate.

2.2. Statistical analysis

The study investigated the relationship between IU (exposure) at wave 0 and depressive symptoms (outcome) at wave 0, IU at wave 1 and depressive symptoms at wave 1 in a cross-sectional manner, as well as the association between IU at wave 1 and depressive symptoms at wave 2 in a prospective manner. Analyses for each wave included observations with complete information on both the intolerance of uncertainty and depressive symptoms. In our analysis, each potential confounder, encompassing demographic characteristics and COVID-19 exposure, was individually assessed for its relationship with the exposure and, separately, with the outcome across each of the three waves. We employed *t*-tests, chi-square tests, and Fisher Exact tests to determine these associations. Only those confounders that yielded a *p*-value of < 0.2 in relation to both the exposure and the outcome were subsequently chosen for inclusion in the multivariable models (Tables 1 and 2). Afterwards, multivariable logistic regression was used to investigate the relationship between intolerance of uncertainty and depressive symptoms in both cross-sectional and prospective associations, controlling for confounders. The crude and adjusted odds ratios (ORs) as well as the 95 % confidence intervals (CIs) were calculated. We also conducted additional analyses: a) accounting for a continuous IU score; b) considering a continuous score of depressive symptoms using linear regression; and c) adjusting for the effect of depressive symptoms at waves 0 and 1. Effect modification for the association of IU and

Table 1
Demographics, COVID-19 exposure, and IU by moderate to severe depressive symptoms in waves 0,1 & 2.

Variable names ^{a,b,c}	Wave 0 (N = 1216)		Wave 1 (N = 925)		Wave 2 (N = 809)	
	No Depressive symptoms (N = 995 (82 %)), N(%) or Mean(SD)	Depressive symptoms (N = 221 (18 %)), N(%) or Mean(SD)	No Depressive symptoms (N = 814 (88 %)), N(%) or Mean(SD)	Depressive symptoms (N = 111 (12 %)), N(%) or Mean(SD)	No Depressive symptoms (N = 737 (91 %)), N(%) or Mean(SD)	Depressive symptoms (N = 72 (9 %)), N(%) or Mean(SD)
Sub-samples						
First study	384 (38.59)	78 (35.29)	339 (41.65)	33 (29.73)	295 (40.03)	26 (36.11)
Second study	210 (21.11)	47 (21.27)	140 (17.20)	26 (23.42)	127 (17.23)	17 (23.61)
Third study	401 (40.30)	96 (43.44)	335 (41.15)	52 (46.85)	315 (42.74)	29 (40.28)
P-value		0.62		0.04		0.4
Youth and parents						
Parents	428 (43.02)	105 (47.51)	368 (45.21)	54 (48.65)	320 (43.42)	39 (54.17)
Youth	567 (56.98)	116 (52.49)	446 (54.79)	57 (51.35)	417 (56.58)	33 (45.83)
P-value		0.25		0.56		0.33
Gender						
Male	372 (37.39)	77 (34.84)	301 (36.98)	41 (36.94)	274 (37.18)	27 (37.50)
Female	623 (62.61)	144 (65.16)	513 (63.02)	70 (63.06)	463 (62.82)	45 (62.50)
P-value		0.53		1		1
Age ^{a,b,c}						
Years	42.93 (16.26)	40.97 (16.99)	42.57 (16.36)	41.39 (17.15)	43.06 (16.60)	39.46 (17.02)
P-value		0.11		0.48		0.08
Job status ^{b,c}						
Jobless	241 (24.22)	63 (28.50)	196 (24.17)	40 (36.04)	180 (24.52)	19 (26.76)
Lost job because of covid	113 (11.36)	39 (17.65)	97 (11.96)	19 (17.11)	86 (11.72)	14 (19.72)
Self-employed/employed	641 (64.42)	119 (53.85)	518 (63.87)	52 (46.85)	468 (63.76)	38 (53.52)
P-value		0.006		0.002		0.1
Religion ^{a,b,c}						
No religion	232 (23.42)	77 (34.84)	208 (25.71)	31 (27.93)	183 (25)	23 (32.86)
Protestant	126 (12.71)	25 (11.31)	95 (11.74)	15 (13.51)	91 (12.43)	6 (8.57)
Catholic, Jewish	520 (52.47)	82 (37.10)	410 (50.68)	48 (43.24)	365 (49.86)	22 (31.43)
Other religions	113 (11.40)	37 (16.74)	96 (11.87)	17 (15.32)	93 (12.70)	19 (27.14)
P-value		0.05		0.8		0.86
Race ^{a,b,c}						
White, Not Hispanic	466 (47.26)	86 (40)	403 (49.94)	47 (43.12)	369 (50.48)	22 (30.99)
Hispanic Black/African American,	280 (28.40)	68 (31.63)	213 (26.39)	33 (30.28)	193 (26.40)	22 (30.99)
Not Hispanic, American Indian/Alaska Native, Not Hispanic Native Hawaiian/Pacific Islander, Not Hispanic	73 (7.40)	20 (9.30)	55 (6.82)	9 (8.26)	44 (6.02)	7 (9.86)
Other race and ethnicity	167 (16.94)	41 (19.07)	136 (16.85)	20 (18.35)	125 (17.10)	20 (28.16)
P-value		0.11		0.33		0.003
Income ^{a,b,c}						
No income-\$ 54,999	207 (23.21)	59 (29.35)	144 (19.73)	37 (37)	130 (19.32)	24 (36.92)
\$55,000 - 99,999	216 (24.22)	57 (28.36)	185 (25.34)	17 (17)	170 (25.26)	14 (21.54)
\$100,000 and over	469 (52.58)	85 (42.29)	401 (54.93)	46 (46)	373 (55.42)	27 (41.54)
P-value		0.03		<0.001		0.004
Marital ^{a,b,c}						
Married and living with spouse, living with a partner as though married	487 (48.99)	87 (39.37)	391 (48.27)	46 (41.44)	349 (47.61)	23 (32.39)
Separated, Divorced and Widowed and not living with someone	113 (11.37)	31 (14.03)	86 (10.62)	13 (11.71)	88 (12.01)	10 (14.08)
Never married and not living with someone	328 (33)	94 (42.53)	283 (34.94)	44 (39.64)	255 (34.79)	35 (49.30)
Other marital status	66 (6.64)	9 (4.07)	50 (6.17)	8 (7.21)	41 (5.59)	3 (4.23)
P-value		0.06		0.2		0.03
Exposure to Covid_19 at base ^{b,c}						
Not having positive test	841 (84.52)	186 (84.17)	695 (85.7)	88 (79.28)	625 (85.15)	64 (90.14)
Having positive test	124 (12.46)	30 (13.57)	92 (11.34)	18 (16.22)	88 (11.99)	5 (7.04)
Receiving medical treatment or being hospitalized	30 (3.02)	5 (2.26)	24 (2.96)	5 (4.50)	21 (2.86)	2 (2.82)
P-value		0.76		0.21		0.46
IU at Wave 0 ^{a,b,c}						
Score < 50th percentile (34)	512 (51.56)	71 (32.27)	424 (52.41)	31 (27.93)	382 (52.11)	18 (25.35)
Score ≥ 50th percentile (34)	481 (48.44)	149 (67.73)	385 (47.59)	80 (72.07)	351 (47.89)	53 (74.65)
P-value		<0.001		<0.001		<0.001
Exposure to Covid_19 at wave 1 ^c						
Not having positive test			273 (33.54)	36 (32.43)	223 (33.63)	21 (36.21)
Having positive test			495 (60.81)	70 (63.07)	402 (60.63)	34 (58.62)
Having positive test and receiving medical treatment or being hospitalized			46 (5.65)	5 (4.50)	38 (5.74)	3 (5.17)

(continued on next page)

Table 1 (continued)

Variable names ^{a,b,c}	Wave 0 (N = 1216)		Wave 1 (N = 925)		Wave 2 (N = 809)	
	No Depressive symptoms (N = 995 (82 %)), N(%) or Mean(SD)	Depressive symptoms (N = 221 (18 %)), N(%) or Mean(SD)	No Depressive symptoms (N = 814 (88 %)), N(%) or Mean(SD)	Depressive symptoms (N = 111 (12 %)), N(%) or Mean(SD)	No Depressive symptoms (N = 737 (91 %)), N(%) or Mean(SD)	Depressive symptoms (N = 72 (9 %)), N(%) or Mean(SD)
P-value				0.84		0.84
IU at Wave 1 ^c						
Score < 50th percentile (31)			424 (52.09)	23 (20.72)	342 (51.66)	13 (22.41)
Score ≥ 50th percentile (31)			390 (47.91)	88 (79.28)	320 (48.34)	45 (77.59)
P-value				<0.001		<0.001
Exposure to Covid_19 at wave 2 ^{a,c}						
Not having positive test					140 (19.02)	11 (15.49)
Having positive test					541 (73.51)	54 (76.06)
Having positive test and receiving medical treatment or being hospitalized					55 (7.47)	6 (8.45)
P-value						0.75

^a Missing information for wave 0: Age, n = 1; Religion, n = 4; Race, n = 15; Income status, n = 123; Marital, n = 1; IU at Wave 0, n = 3.
^b Missing information for wave 1: Age, n = 4, Job status, n = 3; Religion, n = 5; Race, n = 9; Income status, n = 95; Marital status, n = 4; Exposure to Covid_19 at wave 0, n = 3; IU at Wave 0, n = 5.
^c Missing information for wave 2: Age, n = 5; Job status, n = 4; Religion, n = 7; Race, n = 7; Income status, n = 71; Marital status, n = 5; Exposure to Covid_19 at wave 0, n = 4; Exposure to Covid_19 at wave 1, n = 88; Exposure to Covid_19 at wave 2, n = 2; IU at Wave 0, n = 5; IU at Wave 1, n = 89.

depressive symptoms at wave 1 by the financial worries, health worries, social activity worries at wave 1 was evaluated. In addition, the association between IU at wave 1 and depressive symptoms at wave 2 was evaluated in terms of the effect modification of financial worries, health worries, and social activity worries at both waves 1 and 2. The odds ratio with 95 % CIs for each stratum of exposure and modifiers, the odds ratio with 95 % CIs for exposure within strata of modifiers, and tests of interaction on the multiplicative scale were calculated using the R package “interaction R” (Alii, 2021). To test possible heterogeneity in the association between IU and depressive symptoms by study cohort, the interaction term between the study cohort and IU variables was included in the regression models, and P-values for multiplicative scale interaction was checked. We also performed causal mediation analysis using the R package “mediation” to compute the average direct effect (ADE), average causal mediation effect (ACME), and Proportion Mediated (average) (Tingley et al., 2014). All statistical analyses were conducted using R release (2022.07.1) (Team, 2010).

3. Results

The study involved 1 227 participants with a mean age of 42.64, including 690 young adults (56 % of the total sample), and 537 parents of the young adults (44 % of the total sample). Participants were primarily recruited from the first (N = 468, 38 %) and the second sample group (N = 499, 41 %). The rest (N = 260, 21 %) were from the third sample group. The sample predominantly consisted of females, with 774 women compared to 453 men (63 % vs. 37 %, respectively). Regarding ethnicity, 93 (8 %) participants were classified as non-Hispanic, Black/Alaska Native/Indian American/Hawaiian, 353 (29 %) as Hispanic, and 557 (46 %) as non-Hispanic White, and the remaining 209 (17 %) participants were grouped as Other race/ethnicity. Most of participants reported their religion as Catholic and Jewish, accounting for 607 (50 %) of the sample. Meanwhile, 309 (26 %) declared themselves as non-religious, 151 (12 %) as Protestant, and 151 (12 %) as other religions. Concerning employment status, 764 (62 %) of participants were employed or self-employed, 153 (13 %) lost their jobs as a result of COVID-19, and 305 (25 %) were unemployed. Participants without income or earning up to \$54,999 were 268 (22 %), those earning \$55,000–\$99, 999 were 274 (23 %), those earning over \$100,000 were 556 (45 %) and 129 (11 %) did not report their income status. Finally, 577 (47 %) participants in the study were married and lived with others, 147 (12

%) were divorced, separated, or widowed and did not live with others, 422 (35 %) had never been married and lived alone and the remaining 75 (6 %) participants were grouped as Other marital status.

3.1. Association of IU with depressive symptoms and impact of confounder adjustment

As shown in Table 3, there was a positive and robust association between intolerance of uncertainty and depressive symptoms at all waves. After covariate adjustment of race/ethnicity and income for the IU-depressive symptoms association at wave 0, the odds ratio was 2.14 (95 % CI, 1.54–2.99; $p < 0.001$). The adjusted OR with 95 % CI for IU-depressive symptoms association at wave 1 was 4.5 (95%CI, 2.67–7.93; $p < 0.001$) after covariate adjustment of race/ethnicity, income, job, sub-samples, and COVID-19 exposure score at wave 0. Furthermore, the covariates race/ ethnicity, income, age, and job were adjusted for the association between IU at wave 1 and depressive symptoms at wave 2, and the adjusted OR was 3.22 (95 % CI, 1.68–6.63; $p < 0.001$). The cross-sectional association at wave 1 was even stronger (adj OR ~ 4 vs. ~2) for wave 1 vs. wave 0. Association of wave 1 IU with wave 2 depressive symptoms diminished somewhat but was still strong relative to the association of depressive symptoms at wave 1. For all of the associations examined here, adjustment for confounders had modest impact on magnitude of association. The results of the full models were added as supplemental material (Table 1).

The results were consistent across both the dichotomous measures of IU and the continuous measures for IU in logistic regression, as well as the continuous measures for IU and the continuous measures of depressive symptoms in linear regression (see Supplemental Material, Tables 2 and 3). Using a continuous measure for IU and accounting for the effect of depressive symptoms at wave 0 on waves 1, as well as the effect of depressive symptoms at wave 0 and 1 on waves 2, the adjusted OR for the IU-depressive symptoms association at wave 0 was 2.13 for a one IQR increase in IU (95 % CI, 1.54–2.99; $p < 0.001$). The adjusted OR with a 95 % CI for the IU-depressive symptoms association at wave 1 was 3.11 for a one IQR increase in IU (95 % CI, 2.13–4.63; $p < 0.001$). Regarding the association between IU at wave 1 and depressive symptoms at wave 2, the adjusted OR was 2.24 for a one IQR increase in IU (95 % CI, 1.31–3.93; $p < 0.01$).

Table 2
: Demographics, COVID-19 exposure, and moderate to severe depressive symptoms by IU at waves 0 and 1.

Variable names	Wave 0 (N = 1218)		Wave 1 (N = 925)	
	Score of intolerance of uncertainty at wave base < 50th percentile (34) (N = 585 (48 %)), N (%) or Mean (SD)	Score of intolerance of uncertainty at wave base ≥ 50th percentile (34) (N = 633 (52 %)), N (%) or Mean (SD)	Score of intolerance of uncertainty at wave 1 < 50th percentile (31) (N = 447 (48 %)), N (%) or Mean (SD)	Score of intolerance of uncertainty at wave 1 ≥ 50th percentile (31) (N = 478 (52 %)), N (%) or Mean (SD)
Study sub-samples				
First sample	250 (42.74)	214 (33.81)	190 (42.51)	182 (38.08)
Second sample	98 (16.75)	157 (24.80)	66 (14.76)	100 (20.92)
Third sample	237 (40.51)	262 (41.39)	191 (42.73)	196 (41)
P-value		<0.001		0.04
Youth and parents				
Parents	262 (44.79)	271 (42.81)	203 (45.41)	219 (45.82)
Youth	323 (55.21)	362 (57.19)	244 (54.59)	259 (54.18)
P-value		0.52		0.95
Gender				
Male	253 (43.25)	197 (31.12)	202 (45.19)	140 (29.29)
Female	332 (56.75)	436 (68.88)	245 (54.81)	338 (70.71)
P-value		< 0.001		< 0.001
Age ^{a,b}				
Years	42.81 (16.20)	42.41 (17.60)	43.24 (16.10)	41.65 (17.10)
P-value		0.69		0.16
Job status ^b				
Jobless	143 (24.44)	160 (25.28)	109 (24.38)	127 (26.74)
Lost job because of covid	72 (12.31)	80 (12.64)	51 (11.41)	65 (13.68)
Self-employed/employed	370 (63.25)	393 (62.08)	287 (64.21)	283 (59.58)
P-value		0.91		0.32
Religion ^{a,b}				
No religion	148 (25.43)	161 (25.47)	127 (28.48)	112 (23.63)
Protestant	73 (12.54)	78 (12.34)	49 (10.99)	61 (12.87)
Catholic, Jewish	293 (50.35)	311 (49.22)	215 (48.21)	243 (51.27)
Other religions	68 (11.68)	82 (12.97)	55 (12.33)	58 (12.24)
P-value		0.81		0.25
Race ^{a,b}				
White, Not Hispanic	313 (54.06)	241 (38.62)	255 (57.30)	195 (41.40)
Hispanic	143 (24.70)	205 (32.85)	100 (22.47)	146 (31)
Black/African American, Not Hispanic, American Indian/Alaska Native, Not Hispanic Alaska Native, Native Hawaiian/Pacific Islander, Not Hispanic	36 (6.22)	57 (9.14)	29 (6.52)	35 (7.43)
Other race and ethnicity	87 (15.03)	121 (19.39)	61 (13.71)	95 (20.17)
P-value		<0.001		<0.001
Income ^{a,b}				
No income-\$ 54,999	99 (18.86)	167 (29.25)	59 (14.79)	122 (28.31)
\$55000–99,999	132 (25.14)	142 (24.87)	99 (24.81)	103 (23.90)
\$100,000 and over	294 (56)	262 (45.88)	241 (60.4)	206 (47.80)
P-value		<0.001		<0.001
Marital ^{a,b}				
Married and living with spouse, living with a partner as though married	278 (47.60)	297 (46.92)	210 (47.09)	227 (47.79)
Separated, Divorced and Widowed and not living with someone	65 (11.13)	80 (12.64)	44 (9.87)	55 (11.58)
Never married and not living with someone	212 (36.30)	210 (33.18)	167 (37.44)	160 (33.68)
Other marital status	29 (4.97)	46 (7.26)	25 (5.61)	33 (6.95)
P-value		0.71		0.79
Exposure to Covid_19 at wave 0 ^b				
Not having positive test	489 (83.59)	541 (85.46)	379 (84.79)	404 (85.05)
Having positive test	82 (14.02)	71 (11.22)	60 (13.42)	50 (10.53)
Having positive test and receiving medical treatment or being hospitalized	14 (2.39)	21 (3.32)	8 (1.79)	21 (4.42)
P-value		0.23		0.39
Depressive symptoms at wave 0 ^a				
Yes	512 (87.82)	481 (76.35)	382 (86.04)	361 (76.32)
No	71 (12.18)	149 (23.65)	62 (13.96)	112 (23.68)
P-value		< 0.001		< 0.001
Exposure to Covid_19 at wave 1				
Not having positive test			150 (33.56)	159 (33.26)
Having positive test			277 (61.97)	288 (60.25)
Having positive test and receiving medical treatment or being hospitalized			20 (4.47)	31 (6.49)
P-value				0.4
Depressive symptoms at wave 1				
Yes			424 (94.85)	390 (81.59)
No			23 (5.15)	88 (18.41)
P-value				< 0.001

(continued on next page)

Table 2 (continued)

Variable names	Wave 0 (N = 1218)		Wave 1 (N = 925)	
	Score of intolerance of uncertainty at wave base < 50th percentile (34) (N = 585 (48 %)), N (%) or Mean (SD)	Score of intolerance of uncertainty at wave base ≥ 50th percentile (34) (N = 633 (52 %)), N (%) or Mean (SD)	Score of intolerance of uncertainty at wave 1 < 50th percentile (31) (N = 447 (48 %)), N (%) or Mean (SD)	Score of intolerance of uncertainty at wave 1 ≥ 50th percentile (31) (N = 478 (52 %)), N (%) or Mean (SD)
Depressive symptoms at wave 2 ^b				
Yes			342 (96.34)	320 (87.67)
No			13 (3.66)	45 (12.33)
P-value			< 0.001	

^a Missing information wave 0: Age, n = 2, Race, n = 15; Income status, n = 122; Depressive symptoms at wave 0, n = 5, Marital, n = 1; Religion, n = 4.

^b Missing information wave one: Age, n = 4; Job status, n = 3; Religion, n = 5; Race, n = 9; Income status, n = 95; Marital, n = 4; Exposure to Covid_19 at wave 0, n = 3; Depressive symptoms at wave 0, n = 8; Depressive symptoms at wave 2, n = 205.

Table 3

Association of IU at wave 0 with moderate to severe depressive symptoms at wave 0 and IU at wave 1 with waves 1 and 2 using logistic regression models with adjustment for potential confounder variables, considering categorized IU.

	Outcome: Depressive symptoms at wave 0 N = 1213 (18 %)		Outcome: Depressive symptoms at wave 1 N = 925 (12 %)		Outcome: Depressive symptoms at wave 2 N = 720 (9 %)	
	OR (CI 95 %)	P-value	OR (CI 95 %)	P-value	OR (CI 95 %)	P-value
Unadjusted						
IUS > median	2.23 (1.65, 3.06)	< 0.001	4.16 (2.62, 6.86)	< 0.001	3.70 (2.02, 7.26)	< 0.001
Adjusted						
IUS > median	2.14 (1.54, 2.99) ^a	< 0.001	4.50 (2.67, 7.93) ^b	< 0.001	3.22 (1.68, 6.63) ^c	< 0.001

^a Adjusted for race and income.

^b Adjusted for race, income, study sub-samples and COVID exposure at wave 0.

^c Adjusted for race, income, age and job.

3.2. Association of IU with depressive symptoms and effect modification by financial, health and social activity worries

As shown in Tables 4, 5, and 6, although there were numeric differences in odds of IU for depressive symptoms among subjects with

scores below and above the median for financial, health, and social activities worries, the 95 % CI of the interaction odds ratio on the multiplicative scale included 1.0. Consequently, neither cross-sectional nor prospective associations of IU-depressive symptoms were significantly modified by financial, health, or social activities worries.

Table 4

Modification effect of worries at wave 1 on the IU- moderate to severe depressive symptoms association at wave 1.

Variable names	WAVE 1				
	N with/without outcome	OR [95 % CI]	N with/without outcome	OR [95 % CI]	OR [95 % CI]
Financial worries 1					Effect of IU wave 1 within the strata of financial worries 1
IU wave 1 absent*			IU wave 1 present*		
Financial worries 1 absent*	7/240	1 [Reference]	11/131	2.88 [1.09, 7.60]	2.88 [1.09, 7.60]
Financial worries 1 present*	16/184	2.98 [1.20, 7.40]	77/259	10.19 [4.61, 22.54]	3.42 [1.93, 6.05]
Effect of financial worries 1 within the strata of IUS wave 1		2.98 [1.20, 7.40]		3.54 [1.82, 6.89]	
Multiplicative scale interaction		1.19 [0.38, 3.66]			
Health worries 1					Effect of IUS wave 1 within the strata of Health worries 1
IUS wave 1 absent*			IUS wave 1 present*		
Health worries 1 absent*	4/248	1 [Reference]	14/135	6.43 [2.08, 19.91]	6.43 [2.08, 19.91]
Health worries 1 present*	19/176	6.69 [2.24, 20.01]	77/255	17.99 [6.48, 49.94]	2.69 [1.57, 4.61]
Effect of health worries 1 within the strata of IUS wave 1		6.69 [2.24, 20.01]		2.8 [1.52, 5.14]	
Multiplicative scale interaction		0.42 [0.12, 1.46]			
Social activity worries 1					Effect of IUS wave 1 within the strata of social activity worries 1
IUS wave 1 absent*			IUS wave 1 present*		
Social activity worries 1 absent*	5/217	1 [Reference]	19/122	6.76 [2.46, 18.55]	6.76 [2.46, 18.55]
Social activity worries 1 present*	18/207	3.77 [1.38, 10.35]	69/268	11.17 [4.43, 28.18]	2.96 [1.71, 5.13]
Effect of social activity worries within the strata of IUS wave 1		3.77 [1.38, 10.35]		1.65 [0.95, 2.87]	
Multiplicative scale interaction		0.44 [0.14, 1.38]			

* Absent means below the median, and present means above the media.

Table 5
Modification effect of worries wave 1 on the association of IUS at wave 1 and moderate to severe depressive symptoms in wave 2.

Variable names	WAVE 2				
	N with/without outcome	OR [95 % CI]	N with/without outcome	OR [95 % CI]	OR [95 % CI]
Financial worries 1			IU wave 1 absent*	IU wave 1 present*	Effect of IUS wave 1 within the strata of financial worries 1
Financial worries 1 absent*	3/195	1 [Reference]	6/101	3.86 [0.95, 15.76]	3.86 [0.95, 15.76]
Financial worries 1 present*	10/147	4.42 [1.20, 16.35]	39/219	11.58 [3.52, 38.04]	2.62 [1.27, 5.41]
Effect of financial worries 1 within the strata of IUS wave 1		4.42 [1.20, 16.35]		3 [1.23, 7.31]	
Multiplicative scale interaction		0.68 [0.14, 3.3]			
Health worries 1			IU wave 1 absent*	IU wave 1 present*	Effect of IU wave 1 within the strata of Health worries 1
Health worries 1 absent*	4/190	1 [Reference]	6/101	2.82 [0.78, 10.23]	2.82 [0.78, 10.23]
Health worries 1 present*	9/152	2.81 [0.85, 9.31]	39/219	8.46 [2.97, 24.1]	3.01 [1.42, 6.39]
Effect of health worries 1 within the strata of IUS wave 1		2.81 [0.85, 9.31]		3 [1.23, 7.31]	
Multiplicative scale interaction		1.07 [0.24, 4.74]			
Social activity worries 1			IU wave 1 absent*	IU wave 1 present*	Effect of IU wave 1 within the strata of social activity worries 1
Social activity worries 1 absent*	5/172	1 [Reference]	9/101	3.07 [1, 9.40]	3.07 [1, 9.40]
Social activity worries 1 present*	8/170	1.62 [0.52, 5.05]	36/219	5.65 [2.17, 14.72]	3.49 [1.58, 7.71]
Effect of social activity worries 1 within the strata of IUS wave 1		1.62 [0.52, 5.05]		1.84 [0.86, 3.97]	
Multiplicative scale interaction		1.14 [0.29, 4.49]			

* Absent means below the median, and present means above the median.

To test possible heterogeneity in the association between IU and depressive symptoms by study cohort, the interaction term between the study cohort and IU was included in the regression models. *P*-values for multiplicative scale interaction were not statistically significant (0.46, 0.45, 0.88 respectively for wave base line, wave1 and wave 2), therefore these product terms were not retained in models.

3.3. Association of IU with depressive symptoms and mediation by financial, health and social activity worries

As shown in Table 7, all worries partially mediated the cross-sectional and prospective relationships between IU and depressive symptoms. Financial worries mediated 18–37 %, health worries mediated 16–37 %, and social activity worries mediated 12–33 % of the IU-depressive symptoms associations.

4. Discussion

This research aimed to advance our understanding of the relationship between intolerance of uncertainty and depressive symptoms. The key findings revealed a consistent positive association between IU and depressive symptoms across three study waves, even after adjusting for potential confounders. While worries about finances, health, and social activity did not directly modify this link, they partially mediated the relationship between IU and depressive symptoms.

The relationship between intolerance of uncertainty and depressive symptoms has been investigated in other research. Several population-based studies have examined this association longitudinally and cross-sectionally, both prior to and during the COVID-19 pandemic (Del

Valle et al., 2020; Huang et al., 2019; Khawaja and McMahon, 2011). However, the findings from pre-pandemic studies have been mixed, with some indicating a positive correlation between intolerance of uncertainty and depressive symptoms, while others have found no significant relationship between the two (Huang et al., 2019; Khawaja and McMahon, 2011). Interestingly, studies conducted during the COVID-19 pandemic have found a significant association between depressive symptoms and intolerance of uncertainty (Dar et al., 2017; Del Valle et al., 2020). Our study’s findings are consistent with the results of a longitudinal study conducted by Del-Valle and colleagues in Argentina which included 1230 adults, demonstrating that intolerance of uncertainty predicted depressive symptoms and anxiety symptoms, even after an 11-month follow-up (Del-Valle et al., 2022).

Additionally, we investigated the potential impact of COVID-19-related financial, health, and social activity worries on the association between IU and depressive symptoms. To our knowledge, this study was one of the first to examine the effects of these specific COVID-19-related worries as moderators and mediators on IU and depressive symptoms during the COVID-19 pandemic. Unlike other studies that focused solely on one aspect, such as the fear of contracting COVID-19, our study comprehensively examined multiple dimensions of worries (Voitsidis et al., 2021). Also, other studies during the COVID-19 pandemic investigated different variables as moderators/mediators of the relationship between IU and depressive symptoms such as anger (Hamama-Raz et al., 2021). Prior to the COVID-19 pandemic, several studies assessed the link between intolerance of uncertainty and depressive symptoms, specifically examining the role of worry. The Yook et al. study, did not find any evidence of worries mediating the relationship between IU and depressive symptoms (Yook et al., 2010). Meanwhile, Dar et al.

Table 6
Modification effect of worries wave 2 on the association of IU at wave 1 and moderate to severe depressive symptoms at wave 2.

Variable names	WAVE 2				
	N with/without outcome	OR [95 % CI]	N with/without outcome	OR [95 % CI]	OR [95 % CI]
Financial worries 2			IU wave 1 absent*	IU wave 1 present*	Effect of IU wave 1 within the strata of financial worries 2
Financial worries 2 absent*	5/199	1 [Reference]	5/126	1.58 [0.45, 5.57]	1.58 [0.45, 5.57]
Financial worries 2 present*	8/143	2.23 [0.71, 6.95]	40/194	8.21 [3.17, 21.23]	3.69 [1.67, 8.11]
Effect of financial worries 2 within the strata of IUS wave 1		2.23 [0.71, 6.95]		5.2 [2, 13.52]	
Multiplicative scale interaction		2.33 [0.53, 10.32]			
Health worries 2			IU wave 1 absent*	IU wave 1 present*	Effect of IU wave 1 within the strata of health worries 2
Health worries 2 absent*	3/203	1 [Reference]	3/126	1.61 [0.32, 8.10]	1.61 [0.32, 8.10]
Health worries 2 present*	10/139	4.87 [1.32, 18]	42/194	14.65 [4.47, 48.02]	3.01 [1.46, 6.20]
Effect of health worries 2 within the strata of IUS wave 1		4.87 [1.32, 18]		9.09 [2.76, 29.97]	
Multiplicative scale interaction		1.87 [0.32, 10.96]			
Social activity worries 2			IU wave 1 absent*	IU wave 1 present*	Effect of IU wave 1 within the strata of social activity worries 2
Social activity worries 2 absent*	5/214	1 [Reference]	8/138	2.48 [0.8, 7.74]	2.48 [0.8, 7.74]
Social activity worries 2 present*	8/128	2.67 [0.86, 8.35]	37/182	8.7 [3.35, 22.6]	3.25 [1.47, 7.22]
Effect of social activity worries 2 within the strata of IUS wave 1		2.67 [0.86, 8.35]		3.51 [1.58, 7.77]	
Multiplicative scale interaction		1.31 [0.33, 5.26]			

* Absent means below the median, and present means above the median.

concluded that worry both intensified and predicted depressive and anxiety symptoms. Our research during the pandemic identified a partial mediating effect of worries, but not a moderating one (Dar et al., 2017). This disparity may be due to additional influencing factors during the pandemic, such as financial, health, and social support services provided by the US government. Our study took a comprehensive approach, examining various dimensions of concerns related to finance, health, and social activities during the pandemic, compared to the general evaluation of worries in Dar et al.'s study.

This study has some limitations. Firstly, the study relied on self-report measures, which are less valid and reliable than clinical evaluation. The outcome of depressive symptoms used in this study was based on a screening, rather than diagnostic instrument. These aspects may have led to some misclassification of outcome; however, reliance on self-report screening instruments is common in large epidemiological studies. Additionally, if misclassification is non-differential with respect to the exposure, bias would be expected to be towards the null. Secondly, the study was conducted remotely, which may result in a bias in the responses of participants compared to studies conducted in person. Furthermore, we did not control the IU-depressive symptoms association for some other possible confounders such as previous mental health disorders like anxiety, COVID-19 vaccination, their perspective about personal protective equipment (PPE), practices for controlling infection, education level and social, financial and health support which may have an impact on this association. According to the qualitative research conducted by Xiang and colleagues, a significant number of participants showed trust in the effectiveness of appropriate personal protective equipment, practices for controlling infection, and the COVID-19 vaccine as measures for safeguarding themselves against COVID-19 and its serious health implications. This confidence may help to reduce their concerns related to COVID-19 (Ng et al., 2023). Additionally, we evaluated the possible modification effect of COVID-19-related financial, health and social activity worries only at waves 1 and 2. Therefore, it is

possible that their effects at wave 0, during the early stage of the pandemic, may have modified the association between IU and depressive symptoms.

Dichotomization of continuous variables may result in diminished sensitivity in detecting relationships or effects; however, analyses using continuous versions of our IUS and depressive symptom measures yielded consistent results. Furthermore, given the low proportion of missing data (11–12 %), the impact on results is likely to be limited. However, the findings should be interpreted in light of the possibility that the complete-case analysis may have resulted in an underestimation or overestimation of the true associations. In addition, while socioeconomic status fluctuates as time progresses, we did not account for the possibility that factors like income could also change over the same period. Finally, our study was conducted in an urban population in the U.S. with high initial COVID-19 mortality rates, and with a multicultural population diverse in terms of race and religion. This could limit the generalizability of our results to Low- and Middle-Income Countries (LMICs) or to other contexts, such as those with more homogenous populations. Despite these limitations, this prospective cohort study was the first to examine the relationship between intolerance of uncertainty and depressive symptoms, assessing both the modifying and mediating effects of COVID-19-related financial, health, and social activity concerns during the pandemic.

These findings underscore the need for collaboration between policymakers and public health officials to devise effective strategies that support individuals facing intolerance of uncertainty during pandemics. It is crucial to design evidence-based psychological interventions aimed at enhancing resilience and coping abilities, with a particular focus on the behavioral and cognitive dimensions of intolerance of uncertainty. These interventions could serve as potential mechanisms to alleviate the mental health effects of pandemics, such as depressive symptoms (Hebert and Dugas, 2019). Expanding access to mental health services and raising public awareness through campaigns are also vital. To

Table 7

Mediation effect of worries wave 1 and 2 (continuous score) on the association of IU at wave 1 (continuous score) and moderate to severe depressive symptoms at wave 1 and 2 (continuous score).

		IU and depressive symptoms at wave 1				IU at wave 1 and depressive symptoms at wave 2			
		Estimate	95 % CI Lower	95 % CI Upper	p-value	Estimate	95 % CI Lower	95 % CI Upper	p-value
Financial worries 1	ACME	0.04	0.03	0.05	<0.001	0.02	0.01	0.04	<0.001
	ADE	0.13	0.10	0.16	<0.001	0.10	0.06	0.14	<0.001
	Total effect	0.17	0.14	0.20	<0.001	0.12	0.08	0.16	<0.001
	Prop. Mediated	0.23	0.15	0.32	<0.001	0.18	0.07	0.35	<0.001
Health worries 1	ACME (average)	0.04	0.03	0.05	<0.001	0.02	0.01	0.03	<0.001
	ADE (average)	0.13	0.09	0.16	<0.001	0.10	0.06	0.14	<0.001
	Total effect	0.17	0.13	0.20	<0.001	0.12	0.08	0.16	<0.001
	Prop. Mediated (average)	0.25	0.18	0.34	<0.001	0.16	0.07	0.29	<0.001
Social activity worries 1	ACME (average)	0.03	0.02	0.04	<0.001	0.01	0.00	0.03	<0.01
	ADE (average)	0.14	0.10	0.17	<0.001	0.11	0.07	0.14	<0.001
	Total effect	0.17	0.14	0.20	<0.001	0.12	0.08	0.16	<0.001
	Prop. Mediated (average)	0.18	0.11	0.27	<0.001	0.12	0.02	0.23	<0.01
Financial worries 2	ACME (average)					0.04	0.03	0.06	<0.001
	ADE (average)					0.07	0.04	0.11	<0.001
	Total effect					0.12	0.08	0.16	<0.001
	Prop. Mediated (average)					0.37	0.26	0.54	<0.001
Health worries 2	ACME (average)					0.04	0.03	0.06	<0.001
	ADE (average)					0.07	0.04	0.11	<0.001
	Total effect					0.12	0.09	0.16	<0.001
	Prop. Mediated (average)					0.37	0.25	0.52	<0.001
Social activity worries 2	ACME (average)					0.02	0.01	0.04	<0.001
	ADE (average)					0.05	0.01	0.09	<0.05
	Total effect					0.07	0.03	0.11	<0.01
	Prop. Mediated (average)					0.33	0.15	0.68	<0.01

ACME: Average causal mediation effects.

ADE: Average direct effects.

ensure wide accessibility, interventions should be adapted for remote delivery via online platforms. Policymakers and public health officials can identify areas for enhancement and put into action effective measures to mitigate the impact of future pandemics. This knowledge can also guide practitioners in pinpointing vulnerable groups and crafting customized programs and interventions to prevent and treat depressive symptoms during pandemics effectively. This holds significant importance in the long-term management of COVID-19. Many SARS-CoV-2 patients suffer from persistent, quality-of-life impairing symptoms, known as long COVID (Matta et al., 2023). The psychological aspect is increasingly recognized as vital in understanding long COVID, with evidence linking psychological distress to symptom persistence and severity. Recognizing this interplay can help subtype patients and identify biomarkers, potentially improving patient care, while acknowledging that the framework may also explain the link between psychological distress and long COVID risk, as intolerance of uncertainty may be a shared vulnerability factor for both (Lemogne et al., 2023).

5. Conclusion

This study highlights the prevalence of depressive symptoms and its connection to intolerance of uncertainty during the COVID-19 pandemic. The findings indicate that financial, health, and social concerns play a mediating role in this relationship, although they do not appear to modify it. Therefore, our findings suggest that addressing the cognitive, emotional, and behavioral effects of uncertainty is essential in mitigating adverse psychological outcomes during pandemics. Accordingly, promoting tolerance for uncertainty through education and training may serve as an effective psychological strategy in the future. It is crucial to identify factors that lessen the negative consequence of intolerance of uncertainty during pandemics to develop interventions that promote resilience and reduce the global burden of mental health issues.

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CRedit authorship contribution statement

Mojdeh Rafieian: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Norbert Skokauskas:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization. **Keely Cheslack-Postava:** Conceptualization, Data curation, Investigation, Methodology, Supervision, Validation, Writing – review & editing. **Christina W. Hoven:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

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Appendix A. Supplementary Material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jad.2024.04.037>.

References

- Alli, B.Y., 2021. InteractionR: an R package for full reporting of effect modification and interaction. *Software Impacts* 10, 100147.
- Borkovec, T.D., Robinson, E., Pruzinsky, T., DePree, J.A., 1983. Preliminary exploration of worry: some characteristics and processes. *Behav. Res. Ther.* 21, 9–16.
- Boswell, J.F., Thompson-Hollands, J., Farchione, T.J., Barlow, D.H., 2013. Intolerance of uncertainty: a common factor in the treatment of emotional disorders. *J. Clin. Psychol.* 69, 630–645.
- Buhr, K., Dugas, M.J., 2002. The intolerance of uncertainty scale: psychometric properties of the English version. *Behav. Res. Ther.* 40, 931–945.
- Canady, V.A., 2020. APA poll finds nearly half anxious about getting COVID-19. *Ment. Heal. Wkly.* 30, 5.
- Dar, K.A., Iqbal, N., Mushtaq, A., 2017. Intolerance of uncertainty, depression, and anxiety: examining the indirect and moderating effects of worry. *Asian J. Psychiatr.* 29, 129–133.
- De Berardis, D., 2022. How concerned should we be about neurotropism of SARS-Cov-2? A brief clinical consideration of the possible psychiatric implications. *CNS Spectr.* 27, 258–259.
- Del Valle, M.V., Andrés, M.L., Urquijo, S., Yerro-Avincetto, M., López-Morales, H., Canet-Juric, L., 2020. Intolerance of uncertainty over COVID-19 pandemic and its effect on anxiety and depressive symptoms. *Revista Interamericana de Psicología/ Interamerican Journal of Psychology* 54, e1335.
- Del-Valle, M.V., López-Morales, H., Andrés, M.L., Yerro-Avincetto, M., Trudo, R.G., Urquijo, S., Canet-Juric, L., 2022. Intolerance of COVID-19-related uncertainty and depressive and anxiety symptoms during the pandemic: a longitudinal study in Argentina. *J. Anxiety Disord.* 86, 102531.
- Dugas, M.J., Ladouceur, R., 2000. Treatment of GAD: targeting intolerance of uncertainty in two types of worry. *Behav. Modif.* 24, 635–657.
- Dugas, M.J., Gosselin, P., Ladouceur, R., 2001. Intolerance of uncertainty and worry: investigating specificity in a nonclinical sample. *Cogn. Ther. Res.* 25, 551–558.
- Dugas, M.J., Schwartz, A., Francis, K., 2004. Brief report: intolerance of uncertainty, worry, and depression. *Cogn. Ther. Res.* 28, 835–842.
- Fiorillo, A., Gorwood, P., 2020. The consequences of the COVID-19 pandemic on mental health and implications for clinical practice. *Eur. Psychiatry* 63, e32.
- Gentes, E.L., Ruscio, A.M., 2011. A meta-analysis of the relation of intolerance of uncertainty to symptoms of generalized anxiety disorder, major depressive disorder, and obsessive-compulsive disorder. *Clin. Psychol. Rev.* 31, 923–933.
- Grupe, D.W., Nitschke, J.B., 2013. Uncertainty and anticipation in anxiety: an integrated neurobiological and psychological perspective. *Nat. Rev. Neurosci.* 14, 488–501.
- Hamama-Raz, Y., Goodwin, R., Leshem, E., Ben-Ezra, M., 2021. Intolerance of uncertainty and mental health during the COVID-19 pandemic: the role of anger as a moderator. *J. Psychiatr. Res.* 138, 50.
- Hebert, E.A., Dugas, M.J., 2019. Behavioral experiments for intolerance of uncertainty: challenging the unknown in the treatment of generalized anxiety disorder. *Cogn. Behav. Pract.* 26, 421–436.
- Huang, V., Yu, M., Carleton, R.N., Beshai, S., 2019. Intolerance of uncertainty fuels depressive symptoms through rumination: cross-sectional and longitudinal studies. *PLoS One* 14, e0224865.
- Hwang, T.-J., Rabheru, K., Peisah, C., Reichman, W., Ikeda, M., 2020. Loneliness and social isolation during the COVID-19 pandemic. *Int. Psychogeriatr.* 32, 1217–1220.
- Jensen, D., Cohen, J.N., Mennin, D.S., Fresco, D.M., Heimberg, R.G., 2016. Clarifying the unique associations among intolerance of uncertainty, anxiety, and depression. *Cogn. Behav. Ther.* 45, 431–444.
- Khawaja, N.G., McMahon, J., 2011. The relationship of meta-worry and intolerance of uncertainty with pathological worry, anxiety, and depression. *Behav. Chang.* 28, 165–180.
- Kroenke, K., Strine, T.W., Spitzer, R.L., Williams, J.B., Berry, J.T., Mokdad, A.H., 2009. The PHQ-8 as a measure of current depression in the general population. *J. Affect. Disord.* 114, 163–173.
- Kumar, S., Veldhuis, A., Malhotra, T., 2021. Neuropsychiatric and cognitive sequelae of COVID-19. *Front. Psychol.* 12, 577529.
- Lemogne, C., Gouraud, C., Pitron, V., Ranque, B., 2023. Why the hypothesis of psychological mechanisms in long COVID is worth considering. *J. Psychosom. Res.* 165, 111135.
- Matta, J., Robineau, O., Wiernik, E., Carrat, F., Severi, G., Touvier, M., Gouraud, C., Ouazana Vedrines, C., Pitron, V., Ranque, B., 2023. Depression and anxiety before and at the beginning of the COVID-19 pandemic and incident persistent symptoms: a prospective population-based cohort study. *Mol. Psychiatry* 1–11.
- Newman, M.G., Llera, S.J., 2011. A novel theory of experiential avoidance in generalized anxiety disorder: a review and synthesis of research supporting a contrast avoidance model of worry. *Clin. Psychol. Rev.* 31, 371–382.
- Ng, Q.X., Koh, N.Y.K., Xin, X., Zainal, H., Tan, J.T., Thumboo, J., Fong, K.Y., 2023. Experiences of environmental services workers in a tertiary hospital in Asia during the COVID-19 pandemic: a qualitative study. *Front. Public Health* 11, 1178054.
- Salari, N., Hosseini-Far, A., Jalali, R., Vaisi-Raygani, A., Rasoulpoor, S., Mohammadi, M., Rasoulpoor, S., Khaledi-Paveh, B., 2020. Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis. *Glob. Health* 16, 1–11.
- Saulnier, K.G., Allan, N.P., Raines, A.M., Schmidt, N.B., 2019. Depression and intolerance of uncertainty: relations between uncertainty subfactors and depression dimensions. *Psychiatry* 82, 72–79.
- Shu, J., Ochsner, K.N., Phelps, E.A., 2022. Trait intolerance of uncertainty is associated with decreased reappraisal capacity and increased suppression tendency. *Affect. Sci.* 3, 528–538.
- Sojli, E., Tham, W.W., Bryant, R., McAleer, M., 2021. COVID-19 restrictions and age-specific mental health—US probability-based panel evidence. *Transl. Psychiatry* 11, 418.
- Team, R.D.C., 2010. R: A Language and Environment for Statistical Computing. No Title).
- Thompson, C.N., Baumgartner, J., Pichardo, C., Toro, B., Li, L., Arciullo, R., Chan, P.Y., Chen, J., Culp, G., Davidson, A., 2020. COVID-19 outbreak—New York City, February 29–June 1, 2020. *Morb. Mortal. Wkly. Rep.* 69, 1725.
- Tingley, D., Yamamoto, T., Hirose, K., Keele, L., Imai, K., 2014. Mediation: R Package for Causal Mediation Analysis.
- Voitsidis, P., Nikopoulou, V.A., Holeva, V., Parlapani, E., Sereslis, K., Tsipropoulou, V., Karamouzi, P., Giakzoulidou, A., Tsopaneli, N., Diakogiannis, I., 2021. The mediating role of fear of COVID-19 in the relationship between intolerance of uncertainty and depression. *Psychol. Psychother. Theory Res. Pract.* 94, 884–893.
- Wilensky, G.R., 2021. 2020 revealed how poorly the US was prepared for COVID-19—and future pandemics. *JAMA* 325, 1029–1030.
- Wu, J.T., Leung, K., Leung, G.M., 2020. Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. *Lancet* 395, 689–697.
- Yook, K., Kim, K.-H., Suh, S.Y., Lee, K.S., 2010. Intolerance of uncertainty, worry, and rumination in major depressive disorder and generalized anxiety disorder. *J. Anxiety Disord.* 24, 623–628.