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Interoceptive anxiety-related processes: Importance for understanding COVID-19 and future pandemic mental health and addictive behaviors and their comorbidity

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ABSTRACT

The COVID-19 pandemic is associated with an increased prevalence of mental health problems and addictive behaviors. There is a growing theoretical and empirical evidence that individual differences in interoceptive anxiety-related processes are a one set of vulnerability factors that are important in understanding the impact of pandemic-related mental health problems and addictive behavior. However, there has not been a comprehensive effort to explore this rapidly growing body of research and its implications for public health. In this paper, we discuss why interoceptive anxiety-related processes are relevant to understanding mental health and addictive behaviors during the COVID-19 pandemic. We then provide a narrative review of the available COVID-19 literature linking interoceptive fear and anxiety-related processes (e.g., anxiety sensitivity, health anxiety, and COVID-19 anxiety, fear, and worry) to mental health and addictive behaviors. We then propose a novel trans-diagnostic theoretical model that highlights the role of interoceptive anxiety-related processes in mental health and addictive behavior in the context of the present and future pandemics. In the final section, we utilize this conceptualization to underscore clinical implications and provide guidance for future research initiatives in the management of COVID-19 mental health and addictive behaviors and inform the public health field for future pandemics.

The COVID-19 virus, originating in December of 2019 in Wuhan, China, quickly became a global pandemic (Wang, Horby, Hayden, & Gao, 2020). At the present time, there have been 219 million confirmed cases and approximately 4.55 million deaths attributable to COVID-19 (Centers for Disease Control and Prevention, 2021a). The dominant presentation of COVID-19 includes interoceptive symptoms such as fever, chills, cough, sore throat, fatigue, loss of taste and smell, nausea, and diarrhea (Wang et al., 2020). The more severe cases of COVID-19 are associated with respiratory and heart failure, acute respiratory syndrome, and death (Chen et al., 2020). Although the impact of COVID-19 has been and continues to be devastating from a public health perspective, it sits on the backdrop of a large history of viral diseases, including Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome, and Ebola (Ashour, Elkhatib, Rahman, &

Elshabrawy, 2020; Feldmann, Jones, Klenk, & Schnittler, 2003; Novel-Swine-Origin Influenza A (H1N1) Virus Investigation Team et al. (2009), among others. Although the impact of COVID-19 on physical health is substantial (Centers for Disease Control and Prevention, 2021a), the pandemic is also characterized by widespread acute and chronic stress across personal, educational, occupational, and interpersonal realms of functioning (Schmidt, Allan, et al., 2021; Xie et al., 2020).

Numerous reviews and meta-analyses have already comprehensively documented the adverse effects of COVID-19 on mental health and addictive behaviors (Huang & Zhao, 2020; Xiang et al., 2020; Zhang et al., 2020; Zvolensky et al., 2020), with long lasting effects expected (Bao, Sun, Meng, Shi, & Lu, 2020), as has occurred in other pandemics (Bristow, 2012). In terms of mental health during the COVID-19 pandemic, there has been an increase in internet mental health

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symptom searches (Jacobson et al., 2020), greater mental health treatment demand (Titov et al., 2020), and higher rates of mental health problems, including anxiety, depression, and related negative emotional states (e.g., loneliness; Killgore, Cloonan, Taylor, & Dailey, 2020; Reger, Stanley, & Joiner, 2020; Xiang et al., 2020). These mental health effects have also been more robust for certain subpopulations, including racial/ethnic minorities (Mayorga, Garey, et al., 2021). Although studies of children lag behind (Racine, Korczak, & Madigan, 2020), one study found that as many as two-thirds of youth have been significantly impacted by the COVID-19 pandemic, as evidenced by lower quality of life, higher anxiety, and more mental health problems generally than before the pandemic (Ravens-Sieberer et al., 2021, pp. 1–11). However, these results may not generalize to all subgroups of children. For example, mental health outcomes improved among a subset of Latinx children assessed before and at three time points during the pandemic, suggesting potential protective effects (e.g., increased family time, reductions in peer stressors) of stay-at-home orders for this group (Penner, Ortiz, & Sharp, 2021). For addictive behaviors, there has been similar evidence of escalations in substance use and misuse (Rogers, Shepherd, Garey, & Zvolensky, 2020), more severe COVID-19 outcomes among persons with substance use disorder (Raines et al., 2021; Wang, Kaelber, Xu, & Volkow, 2021), and evidence of robust patterns of coping-oriented addictive behavior (e.g., smoking or drinking to downregulate negative mood; Shepherd, Fogle, Garey, Viana, & Zvolensky, 2021) as well as higher levels of functional impairment related to use (in press Abarno, Glover, Morris, Zvolensky, & Buckner). Beyond singular effects of COVID-19 on mental health and addictive behaviors, there is likely an interplay between mental health and addictive behaviors during the pandemic. The occurrence and co-occurrence of mental health and addictive disorders are also likely related to increased prevalence of chronic illnesses in future generations (Zvolensky et al., 2020). The addictive-related consequences of COVID-19 and other (future) pandemics is therefore alarming and in need of scientific attention.

Despite the clinical importance of mental health problems and addictive disorders in the context of the COVID-19 pandemic, there has been little effort to offer an integrated theoretical model for such problems that can be used to guide research in the current and future pandemics. In this paper, we explore the importance of interoceptive fear and anxiety as transdiagnostic psychological mechanisms related to COVID-19 mental health and addictive behaviors. In the first part of the paper, we discuss why interoception (i.e., processing of internal bodily stimuli), and interoceptive anxiety-related processes more specifically, are likely highly relevant to understanding COVID-19 mental health and addictive behaviors. In the second section, we provide a narrative review of the available COVID-19 literature linking interoceptive fear and anxiety-related processes (e.g., anxiety sensitivity, health anxiety, and COVID-19 anxiety, fear, and worry) to mental health and addictive behaviors; we also highlight what is known about the directionality of such work as well as mediating and moderating factors in such relations. In the third section, we propose a novel theoretical transdiagnostic model that highlights the role of interoceptive fear, anxiety, and worry in mental health and addictive behaviors in the context of the present and future pandemics. In the final section, we draw upon this conceptualization to highlight core clinical implications and provide guidance for future research initiatives in the management of COVID-19 mental health and addictive behaviors as well as inform public health knowledge for future pandemics.

1. Interoceptive anxiety-related processes and the pandemic

We suggest that there is merit to harnessing knowledge about interoceptive processes, particularly anxiety-related concerns, in terms of better understanding and addressing COVID-19 related negative effects on mental health and addictive behaviors. This perspective is in line with the network theory suggesting a causal interaction between mental health symptoms within a network (Borsboom, 2017). Although

interoceptive anxiety-related processes are not the only set of psychological mechanisms relevant to behavioral health, they represent a logical and theoretically relevant domain (somatic and disease specific) wherein knowledge can be leveraged and clinically significant advances in prevention and intervention programming can be developed and utilized.

1.1. Interoception

Interoception reflects basic processes such as receiving, processing, and integrating body-relevant signals with contextual factors to modulate behavior (Craig, 2002). Interoceptive processing occurs across all major biological systems (Jänig, 1996). Interoception is theorized to serve a homeostatic function (Craig, 2002). For example, an individual may seek help (e.g., medical care) when they perceive illness-related symptoms (e.g., coughing, fever) and not seek such care if they do not perceive such internal symptoms as illness-related. The act of sensing, interpreting, and integrating information about somatic states is associated with distinct components, including attention, detection, discrimination, and accuracy (Vaitl, 1996). For instance, interoceptive processes includes perceiving somatic-related stimuli in terms of their presence (Pollatos, Kirsch, & Schandry, 2005), sensitivity (Hözl, Erasmus, & Möltner, 1996), and precision (Fealey, 2013). A large volume of research across several disciplines has indicated that interoception is integral to associative learning, stress modulation, reward learning, decision-making, emotional functioning, and cognitive control (Craig, 2003, 2008). Indeed, interoception is a core element in cognitive-affective processing (i.e., cognitive and emotional states are linked or understood in terms of change in bodily states). For example, interoceptive processes can involve associating a rapid heartbeat to a specific emotional state like anxiety (Winkielman, Niedenthal, & Oberman, 2008), which can elicit escape/avoidance to potentially threatening stimuli or contexts (Tataranni et al., 1999).

1.2. COVID-19 pandemic and interoceptive signaling

Based on several lines of evidence, COVID-19 and other pandemics provide a fertile basis for ‘interoceptive signaling’ which is body-relevant signals that are received, processed, and integrated with contextual factors to modulate behavior. First, COVID-19 and related viral infections triggers a wide range of acute and potentially chronic flu-like (e.g., coughing, sneezing) and cardiorespiratory symptoms (Centers for Disease Control and Prevention, 2021a). These symptoms are a direct source of potential interoceptive threat (i.e., body-relevant signals that are perceived as potentially threatening). Even in the absence of direct infection, exposure or possible exposure to COVID-19 would be expected to be related to increased awareness to interoceptive sensations associated with the virus. Second, pandemic related stressors across life domains (e.g., work, recreation, educational, interpersonal, financial) due to a myriad of events (e.g., travel restrictions, virtual learning, job loss, misinformation about the virus) will elicit a range of psychosomatic interoceptive sensations; effects evident at the subjective, neuroendocrine, interpersonal, and peripheral levels of analysis (Lupien, Juster, Raymond, & Marin, 2018; McEwen, Nasca, & Gray, 2016). Third, ongoing coping with dynamic pandemic related events (especially when chronic) contribute to a potential depletion of self-regulation resources, increasing the probability of internal symptoms such as fatigue, sleep impairment, and physical symptoms (e.g., headaches; Kuntz, 2021). Fourth, some of the protective ‘behavioral health strategies’ recommended to reduce viral infection, such as mask wearing and vaccinations, can elicit acute bodily sensations (e.g., difficulty breathing, soreness; Centers for Disease Control and Prevention, 2021b).

Fifth, the pandemic has led to social isolation in efforts to thwart the spread of the virus, with large segments of the population engaging in societal lockdowns (Montemurro, 2020). These mandated lockdowns

were often lifted, then reinstated, involving an element of unpredictability (Sahu, 2020). Although many of these social restrictions are presently loosened or removed, re-integration into social contexts (e.g., work, school, travel) is likely to be, at least initially, related to interoceptive disturbances (i.e., disruptions or changes to body-relevant signals) and a prominent chronic threat-based issue (e.g., new normalcy) for some (Albery, Spada, & Nikčević, 2021). Sixth, numerous studies suggest the pandemic has been related to sleep interference for large segments of the population (Voitsidis et al., 2020). Seventh, persons who experience longer-term COVID-19 symptoms (e.g., “long haulers”) will, by definition, be more likely to have ongoing somatic perturbation (Antonelli et al., 2021). Finally, potentially traumatic events related to COVID-19 (e.g., job loss, exposure to death, lengthy hospitalizations, inability to hold certain events like funerals) will have acute and potentially chronic effects on internal symptoms such as arousal and intrusive thoughts and memories (Bo et al., 2021). Overall, these various sources of pandemic-related internal stimuli represent potent sources of threat-based bodily information.

1.3. Interoceptive-anxiety related processes as transdiagnostic vulnerability factors

The underlying cause of many forms of emotional symptoms and disorders and addictive behaviors may be underpinned by a smaller set of transdiagnostic vulnerability processes (Dozois, Seeds, & Collins, 2009; Sauer-Zavala et al., 2012). In terms of mental health and addictive behaviors, reactive transdiagnostic vulnerabilities, which denote characteristic maladaptive responses to emotion stimuli and states have been among the most promising (Rogers & Zvolensky, 2021; Wolitzky-Taylor et al., 2016; Zvolensky, Rogers, et al., 2018). These types of vulnerabilities play a key explanatory role in emotion experience by enhancing or diminishing the intensity of the emotional response (Leventhal & Zvolensky, 2015).

Interoceptive anxiety, worry, and fear (fear or anxiety about sensations within the body or health status) are among the most prominent transdiagnostic processes in non-COVID-19 research that is focused on mental health and addictive behaviors (Sinha, 2008; Zvolensky, Garey, Kauffman, & Manning, 2019, pp. 101–120). Various individual differences in interoceptive anxiety, worry, and fear (hereafter labeled in this paper as ‘interoceptive anxiety-related processes’ for ease of presentation) have been central explanatory elements in models of psychopathology (Melzig, Holtz, Michalowski, & Hamm, 2011), addictive behaviors (LaRowe, Zvolensky, & Ditre, 2019), functional syndromes (Vlaeyen et al., 2004), and psychological co-morbidity with chronic illnesses (de Gier, Peters, & Vlaeyen, 2003). Historically, there have been several constructs that are characterized by interoceptive fear or anxiety, most notably anxiety in anticipation of pain-related experiences (e.g., fear during the experience of pain; Rogers, Gallagher, et al., 2020), heart-focused anxiety (Mayorga, Shepherd, Garey, Viana, & Zvolensky, 2021), fear of pain (Vlaeyen, De Jong, Onghena, Kerckhoffs-Hanssen, & Kole-Snijders, 2002), anxiety sensitivity (fear about the negative consequences of anxiety sensations; Taylor et al., 2007), suffocation fear (fears about breathing dysregulation; McNally & Eke, 1996), and health anxiety (anxiety focused on health status or symptoms; Blakey & Abramowitz, 2017). There also is emerging research on theoretically relevant interoceptive anxiety, worry, and fear constructs that are specific to the COVID-19 virus (or future pandemics; Schmidt, Allan, et al., 2021). This growing anxiety-related COVID-19 literature has the potential to represent narrower pandemic-specific interoceptive anxiety-related constructs.

2. Narrative review

2.1. Study selection criteria for the literature review

Studies were included in the current review if they (a) specifically

examined an interoceptive fear or anxiety construct, (b) focused on COVID-19 mental health or substance use, and (c) met the standards of empirical testing with psychometrically sound measurement (commentary and measurement papers were excluded). We conducted a literature search (09/21/2021) utilizing electronic search engines (i.e., PsycINFO and MEDLINE) of articles published from March 2020 to the current period to examine databases using the following key word algorithms:

“anxiety sensitivity” OR “suffocation fear” OR “interoceptive fear” OR “health anxiety” OR “pain anxiety” OR “worry about bodily sensations” OR “COVID-19 Worry” OR “COVID-19 fears” OR “COVID-19 anxiety”) AND (“coronavirus” OR “covid-19” OR “pandemic” OR “covid” OR “sars-cov-2”) AND (“mental health” OR “mental illness” OR “mental disorder” OR “psychiatric illness” OR “substance abuse” OR “substance use” OR “drug abuse” OR “drug addiction” OR “drug use” OR “addiction”)

Fig. 1 shows the PRISMA systematic review chart with dates included in the search. First, records were identified in each database and duplicate articles were removed. Then, following initial article identification, titles and abstracts were screened for inclusion/exclusion criteria. Of those eligible based on title and abstract, article full texts were further examined with respect to inclusion/exclusion criteria. Most of these articles were not relevant to the present review because they were not focused specifically on an anxiety-related interoceptive construct within the context of mental health and addictive behaviors (see Fig. 1). In fact, although our search terms included a wide array of interoceptive anxiety-related constructs that have been identified in non-COVID-19 research (e.g., pain-related anxiety), only a select number have thus far received scientific attention in terms of the current pandemic. We therefore provide a narrative review of the available work, which has largely focused on anxiety sensitivity, health anxiety, and COVID-19 fear, anxiety, and worry. We do not believe that these constructs are the only relevant interoceptive anxiety-related constructs. However, there has been enough empirical work on them to warrant a review and represent a model for other relevant factors in future research. We have organized the review by specific constructs for ease of presentation. We (a) first define each construct, discuss its theoretical basis, relations to behavioral health and measurement, (b) discuss its theoretical relevance to pandemic mental and addictive behavior, and (c) review the available empirical literature (cross-sectional and longitudinal) in terms of its association with mental health and addictive behaviors during the COVID-19 pandemic. When possible, we highlight potential bi-directional relations between these constructs and mental health/addictive behaviors and review any evidence of mediation or moderation.

2.2. Anxiety sensitivity

Definition and theoretical basis, relations to behavioral health, and measurement. The anxiety sensitivity construct reflects the extent to which individuals believe anxiety and anxiety-related sensations (e.g., racing heart) have harmful personal consequences (McNally, 2002). It is a relatively stable, but malleable, construct (Taylor, 1999). The global anxiety sensitivity construct encompasses lower-order fears of physical, mental, and publicly observable experiences (Zinbarg, Barlow, & Brown, 1997). Anxiety sensitivity is theorized to amplify anxiety-related responding to somatic perturbation. For example, persons higher in anxiety sensitivity are more likely to be frightened of respiratory symptoms because they believe these sensations will lead to dysfunction (e.g., difficulty breathing) or other feared outcomes, whereas individuals lower in anxiety sensitivity do not fear these sensations because they believe them to be benign. The anxiety sensitivity construct is believed to be influenced by learning processes (e.g., fear conditioning, modeling of fearful behavior or sick-role behavior; Watt, Stewart, & Cox, 1998), exposure to stressful life events (Schmidt, Lerew, & Joiner, 2000), and genetic factors (Jang, Stein, Taylor, & Livesley,

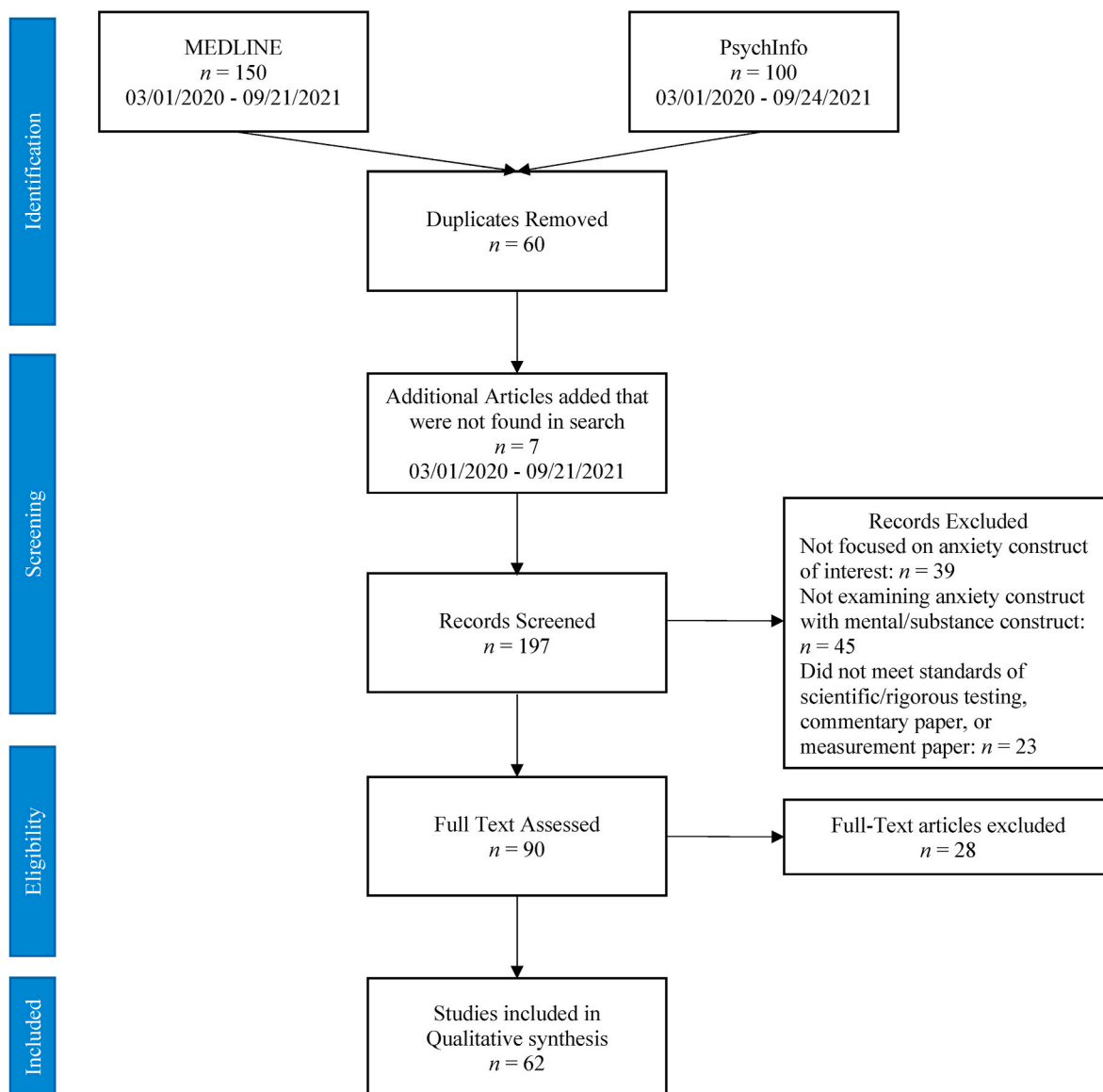


Fig. 1. PRISMA Table.

1999).

Research has established that anxiety sensitivity is distinguishable from the tendency to experience more frequent anxiety symptoms (trait anxiety) and other negative affect propensity variables (e.g., neuroticism; Rapee & Medoro, 1994; Zvolensky, Kotov, Antipova, & Schmidt, 2003). There is empirical evidence across a range of populations that anxiety sensitivity predisposes individuals to the development and maintenance of anxiety and mood psychopathology and related behavioral health problems (Schmidt et al., 1997, 1999, 2000). Also, meta-analytic evidence suggests that this construct is associated with shared variance among emotional disorders and symptom severity among individual disorders (Naragon-Gainey, 2010). Other work has shown anxiety sensitivity is related to threat-relevant bodily kinematics (Bakhshaei, Lebowitz, Schmidt, & Zvolensky, 2020), attentional biases for threat (Richards & Bertram, 2000; Taake, Jaspers-Fayer, & Liotti, 2009), and startle response (McMillan, Asmundson, Zvolensky, & Carleton, 2012). Further, reducing anxiety sensitivity is a mechanism of positive treatment gains for emotional disorders and addictive behaviors (Smits, Powers, Cho, & Telch, 2004; Zvolensky, Rosenfield, et al., 2018).

Although historically measured with the Anxiety Sensitivity Index (Reiss, Peterson, Gursky, & McNally, 1986) or expanded versions of this

measure (Taylor & Cox, 1998), in the recent time period, the anxiety sensitivity construct has most commonly been measured with the Anxiety Sensitivity Index – 3 (Taylor et al., 2007), the Short Scale Anxiety Sensitivity Index (Zvolensky, Rosenfield, et al., 2018), and among youth, the Child Anxiety Sensitivity Index (Silverman, Fleisig, Rabian, & Peterson, 1991). These scales have showcased measurement improvement relative to earlier assessment instruments (Jardin et al., 2018). These psychometrically validated measures ask respondents to indicate their agreement with several statements that pertain to physical, mental, and publicly observable experiences of anxiety (e.g., “when my heart is beating fast, I worry that I may be having a heart attack”).

Theoretical applicability to pandemic. In brief, anxiety sensitivity may theoretically be related to pandemic behavioral health for several reasons. First, anxiety sensitivity may amplify emotional distress related to virus exposure or stress attributable to the pandemic (e.g., worry about the negative consequences of virus exposure, missed educational opportunities, change in “normal” lifestyle). Second, anxiety sensitivity may be related to greater escape/avoidance response tendencies for pandemic-related (threat-based) stimuli (e.g., avoidance of social activities due to fears about the negative consequences of viral exposure). Third, anxiety sensitivity may increase the probability that bodily

sensations are experienced more intensely. Finally, recognizing bidirectional relations, pandemic-related mental health symptoms may contribute to heightened anxiety sensitivity by increasing self-focused attention to bodily sensations and anxiety-related sensations as well as thoughts about the causes and consequences of such symptoms. Non-COVID-19 research would support each of the aforementioned lines of reasoning (Otto et al., 2016). The core aspects of studies on anxiety sensitivity during the pandemic in terms of mental health and addiction can be found in Table 1 in the supplementary materials.

Cross-sectional and longitudinal studies on anxiety sensitivity in terms of mental health and pandemic sequelae. There have been several studies focused on the role of anxiety sensitivity in terms of mental health and COVID-19 anxiety and fear. In a cross-sectional study focused on healthcare personnel (e.g., doctors, nurses; $n = 527$) in Turkey during the pandemic, scholars found the anxiety sensitivity physical concerns to be significantly related to fear of COVID-19; effects larger than that observed for anxiety or depressive symptoms as predictors (Karadem, Demirdaş, Işık, & Kılıç, 2021). In a cross-sectional investigation of 438 university students in the United States (U.S.), Ojalehto, Abramowitz, Hellberg, Butcher, and Buchholz (2021) found that anxiety sensitivity physical concerns were associated with more intense COVID-19 anxiety.

Similar findings have been evident in a representative sample of adults in the U.S. during the pandemic ($n = 5023$; Warren et al., 2021). Global anxiety sensitivity was related to more severe COVID-19 fear, anxiety, and depression at a cross-sectional level. Examination of the lower-order factors revealed that the physical concerns dimension was the more robust predictor of COVID-19 fear, cognitive concerns for anxiety and depression. In a longitudinal test of anxiety sensitivity among 249 adults in the U.S., there was evidence of a significant 1-month longitudinal association between this construct and COVID-19 worry and depression (Schmidt, Morabito, Mathes, & Martin, 2021). Two cross-sectional investigations have extended past work to Latinx populations in the U.S. and South America. Using separate adult samples from Argentina, Rogers et al. (2021) examined the association of anxiety sensitivity with COVID-19 worry, functional impairment, anxiety across two samples: a community sample ($n = 105$) and a clinical sample comprised of individuals with an anxiety disorder ($n = 99$). The findings were consistent for both samples wherein global anxiety sensitivity was related to the studied criterion variables and these effects were evident beyond the variance explained by age, sex, pre-existing medical conditions, and COVID-19 exposure (see Table 1 in the supplementary materials for lower-order relations with criterion variables). Among Latinx adults in the U.S., Mayorga, Garey, et al. (2021) examined anxiety sensitivity during the pandemic among 188 adults. Here, in a cross-sectional examination, anxiety sensitivity was significantly related to the emotional impact of COVID-19 social distancing and economic adversity as well as physical health symptom severity and fear of COVID-19; the effects were evident after adjusting for other theoretically and empirically relevant factors of gender, years living in the U.S., education, and work and home life COVID-19-related stressors.

2.3. Mediation and moderation studies on anxiety sensitivity and mental health and addiction

In a study of Chinese adults ($n = 464$) during the early stages of the pandemic, anxiety sensitivity physical and cognitive concerns (lower-order dimensions) were evaluated cross-sectionally in terms of the relationship between attentional control (ability to regulate attention to positive or negative stimuli; Derryberry & Reed, 2002) and anxiety symptom severity (Guo, Yang, Elhai, & McKay, 2021). There was evidence of a mediational effect for physical and cognitive concerns in terms of partially explaining the association between attentional control ability and anxiety symptom severity. Paluszek et al. (2021) examined the longitudinal role (1-month) of anxiety sensitivity in terms of excessive fear and worry in response to the COVID-19 pandemic in a sample of adults from North America (Canada and the U.S.; $n = 3062$).

Results indicated that greater anxiety sensitivity physical concerns predicted more severe COVID stress syndromes over and above the variance explained by gender, pre-existing mental health disorder, and history of COVID-19 diagnosis. Significant interactions of anxiety sensitivity physical concerns with disgust propensity and sensitivity were also evident. An alternative model proposed by Warren et al. (2021) documented the directional effect of COVID-19 fear, anxiety sensitivity, and mental health outcomes and found that COVID-19 fear mediated the relationship between global anxiety sensitivity with anxiety (17% of effect) and depression (16% of effect). Although this initial cross-sectional work provides a foundation for the interrelations among these variables, longitudinal methods are needed to clarify the unique role and contribution of anxiety sensitivity, COVID-19 emotional response constructs, and behavioral health outcomes.

A cross-sectional study conducted in Israel among a large sample of adults ($n = 828$) evaluated the main and interactive effects of anxiety sensitivity and subjective age (i.e., how young, or old individuals experience themselves to be) in terms of anxiety and depressive symptom severity during the pandemic (Avidor, Abu Hamam, & Lahav, 2021). Here, there was evidence of main effects for anxiety sensitivity (2–3 times larger than the effects for subjective age). Further, an interplay between anxiety sensitivity and subjective age was found (5%–6% of unique variance), such that higher levels of anxiety sensitivity were more strongly related to pandemic depression and anxiety among those with an older subjective age. Among a large sample of Chinese adults (mostly female) early in the pandemic ($n = 908$), anxiety sensitivity physical concerns moderated disgust sensitivity and propensity in terms of fear of contracting COVID-19 (McKay, Yang, Elhai, & Asmundson, 2020).¹ In a cross-sectional test, Manning et al. (2021) explored the moderating role of anxiety sensitivity in the relation between COVID-19 specific perceived stress and global anxiety symptom severity, anxious arousal symptom severity, and functional impairment among 563 adults from the U.S.. Results indicated a statistically significant interaction between COVID-19 perceived stress and anxiety sensitivity with global anxiety symptom severity, anxious arousal symptom severity, and functional impairment. The form of the interaction illustrated that COVID-19 perceived stress was associated with an increased likelihood of clinically significant global anxiety symptom severity, anxious arousal symptom severity, and functional impairment at higher levels of anxiety sensitivity.

In the only study to our knowledge focused on youth and substance use during the pandemic, adolescents ($n = 2120$) were evaluated over time during COVID-19 in terms of an array of emotional symptoms and substance use (Cho, Bello, Christie, Monterosso, & Leventhal, 2021). Participants completed surveys of validated emotional symptom measures and anxiety sensitivity (among other constructs) before the pandemic and were followed up during the pandemic (spring of 2020). Results revealed that baseline anxiety sensitivity was related to higher number of past-month single-substance using days and total number of substances used at follow-up. Moreover, the anxiety sensitivity-substance use associations were mediated by coping motives for pandemic stress.

Summary of existing work. There is a burgeoning area of research on anxiety sensitivity and pandemic-related mental health and addiction. Despite the short window of time for this research to be conducted, strengths of this body of work include valid and reliable assessment of anxiety sensitivity and mental health and addictive processes, large sample sizes in many of the studies, and work that has been conducted from a global perspective (i.e., several countries represented). There is strong empirical evidence that anxiety sensitivity is related to poorer pandemic mental health. Further, there is some research documenting a mediational role of anxiety sensitivity in terms of other risk factors (e.g.,

¹ Authors also describe this construct as “COVID-19 anxiety.” These terms are synonymous with one another.

Table 1
Anxiety Sensitivity as a Predictor of Mental Health and Substance Use.

Author	Sample	Country/Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
Cross-sectional Design					
Avidor et al., (2021)	828 adults; age range 18–79 years	Israel	Anxiety sensitivity (<i>Anxiety Sensitivity Index—Revised</i>)	Anxiety and depressive symptoms (<i>Brief Symptom Inventory-18</i>)	Predictors of anxiety symptoms: (1) anxiety sensitivity ($\beta = .51$; main effect) (2) subjective age*anxiety sensitivity ($\beta = .05$; interaction effect) Predictors of depressive symptoms: (1) anxiety sensitivity ($\beta = .36$; main effect) (2) subjective age*anxiety sensitivity ($\beta = .06$; interaction effect)
Guo et al., (2021)	464 adults; age 18+ years	China	Anxiety sensitivity physical and cognitive concerns (<i>Anxiety Sensitivity Index-3: Physical and cognitive concerns subscales</i>)	Anxiety (<i>Depression Anxiety Stress Scale-21-Anxiety subscale</i>)	Predictors of anxiety: (1) anxiety sensitivity physical concerns ($\beta = 0.284$; direct effect) (2) anxiety sensitivity cognitive concerns ($\beta = 0.517$; direct effect) (3) attention control through anxiety sensitivity physical concerns ($ab = -0.066$; mediation effect) (4) attention control through anxiety sensitivity cognitive concerns ($ab = -0.142$; mediation effect)
Manning et al., (2021)	563 adults; age 18+ years	United States	Anxiety sensitivity (<i>Anxiety Sensitivity Index-3</i>) COVID-19 perceived stress (<i>Perceived Stress Scale Due to COVID-19</i>)	Anxiety (<i>Overall Anxiety Severity and Impairment Scale</i>) Anxious arousal (<i>Panic Disorder Severity Scale</i>) Functional impairment (<i>Work and Social Adjustment Scale</i>)	Predictors of anxiety: (1) anxiety sensitivity ($sr^2 = .00$; main effect) (2) COVID-19 perceived stress*anxiety sensitivity ($sr^2 = .01$; interaction effect) Predictors of anxious arousal symptoms: (1) anxiety sensitivity ($sr^2 = .23$; main effect) (2) COVID-19 perceived stress*anxiety sensitivity ($sr^2 = .02$; interaction effect) Predictors of functional impairment: (1) anxiety sensitivity ($sr^2 = .26$; main effect) (2) COVID-19 perceived stress*anxiety sensitivity ($sr^2 = .01$; interaction effect)
Mayorga, Garey, et al., 2021	188 Latinx persons; age range 18–65 years	United States	Anxiety sensitivity (<i>Short Scale Anxiety Sensitivity Index</i>)	Emotional impact of social distancing and economic adversity (<i>Emotional Impact of Covid-19</i>) Physical health symptom severity (<i>COVID-19 Health Symptom Severity</i>) Fear of COVID-19 (<i>Fear of Coronavirus-19 Scale</i>)	Predictors of emotional impact of social distancing: (1) anxiety sensitivity ($sr^2 = .39$) Predictors of emotional impact of economic adversity: (1) anxiety sensitivity ($sr^2 = .39$) Predictors of physical health symptom severity: (1) anxiety sensitivity ($sr^2 = .16$) Predictors of fear of COVID-19: (1) anxiety sensitivity ($sr^2 = .42$)
McKay et al., (2020)	908 adults; age range 17–64 years	China	Anxiety sensitivity physical concerns (<i>Anxiety Sensitivity Index-3: Physical Concerns subscale</i>) Disgust propensity and sensitivity (<i>Disgust Propensity and Sensitivity Scale-Revised: Propensity and sensitivity subscales</i>)	Fear of contracting COVID-19 (<i>Generalized Anxiety Disorder Scale-7 for COVID-19 Anxiety</i>)	Predictors of fear of contracting COVID-19: (1) anxiety sensitivity physical concerns ($\beta = .14$ and $\beta = .11$; main effect with disgust propensity and sensitivity, respectively) (2) anxiety sensitivity*disgust propensity ($\beta = .07$; interaction effect) (3) anxiety sensitivity*disgust sensitivity ($\beta = .11$; interaction effect)
Ojalehto et al., (2021)	438 university affiliates; age range 17–88 years	United States	Anxiety sensitivity physical concerns (<i>Anxiety Sensitivity Index-3: Physical concerns subscale</i>)	COVID-19 anxiety (<i>Coronavirus Anxiety Scale</i>)	Predictors of COVID-19 anxiety: (1) anxiety sensitivity physical concerns ($sr^2 = .10$)
Rogers et al., (2021)	Study 1: 105 Spanish-speaking adults seeking mental health services for anxiety or depression; age 18+ years Study 2: 99 Spanish-speaking adults with a diagnosis of an anxiety disorder seeking mental	Argentina	Anxiety sensitivity global, physical, cognitive, and social concerns (<i>Anxiety Sensitivity Index-3: Total score and physical, cognitive, and social concerns subscales</i>)	COVID-19 worry (<i>COVID-19 Worry Index</i>) COVID-19 functional impairment (<i>COVID-19 Functional Impairment Scale</i>) COVID-19 anxiety (<i>Anxiety about the Consequences of COVID-19</i>)	Predictors of COVID-19 worry: Study 1 (1) anxiety sensitivity ($sr^2 = .29$) (2) anxiety sensitivity physical concerns ($b = 1.50$; $se = .38$) Study 2 (1) Anxiety sensitivity ($sr^2 = .23$) (2) anxiety sensitivity physical concerns ($b = 1.03$, $se = 0.25$)

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Table 1 (continued)

Author	Sample	Country/ Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
	health services for anxiety or depression; age 18+ years				(3) anxiety sensitivity social concerns ($b = 1.03, se = 0.27$) Predictors of COVID-19 functional impairment: Study 1 (1) Anxiety sensitivity ($sr^2 = .18$) (2) Anxiety sensitivity cognitive concerns ($b = 0.26; se = 0.26$) Study 2 (1) Anxiety sensitivity ($sr^2 = .07$) Predictors of COVID-19 anxiety: Study 1 (1) Anxiety sensitivity ($sr^2 = .07$) (2) Anxiety sensitivity social concerns ($b = 0.42, se = 0.20$) Study 2 (1) Anxiety sensitivity ($sr^2 = .14$) (2) anxiety sensitivity physical concerns ($b = 0.23, se = 0.10$) (3) anxiety sensitivity social concerns ($b = 0.32, se = 0.11$)
Warren et al., (2021)	5023 adults; age range 18–97 years	United States	Anxiety sensitivity global, physical, cognitive, and social concerns (<i>Anxiety Sensitivity Index-3: Total score and physical, cognitive, and social concerns subscales</i>)	COVID-19 fear (<i>Fear of COVID-19 Scale</i>) Anxiety (<i>Generalized Anxiety Disorder 7-item Scale</i>) Depression (<i>Patient Health Questionnaire 8—Item</i>)	Predictors of COVID-19 fear: (1) anxiety sensitivity ($\beta = .19$) (2) anxiety sensitivity physical concerns ($\beta = .34$ and OR = 1.93) (3) anxiety sensitivity cognitive concerns ($\beta = .24$ and OR = 1.56) Predictors of anxiety: (1) anxiety sensitivity ($\beta = .22$) (2) anxiety sensitivity physical concerns ($\beta = .11$ and OR = 1.32) (3) anxiety sensitivity cognitive concerns ($\beta = .39$ and OR = 2.0) (4) anxiety sensitivity social concerns ($\beta = .17, OR = 1.46$) (5) anxiety sensitivity through COVID-19 fear ($ab = 0.038$; mediation effect) Predictors of depression: (1) anxiety sensitivity ($\beta = .20$) (2) anxiety sensitivity physical concerns ($\beta = .07$ and OR = 1.18) (3) anxiety sensitivity cognitive concerns ($\beta = .41$ and OR = 2.26) (4) anxiety sensitivity social concerns ($\beta = .14$ and OR = 1.17) (5) anxiety sensitivity through COVID-19 fear ($ab = 0.032$; mediation effect) Predictors of fear of COVID-19: (1) anxiety sensitivity physical concerns ($\beta = .286$)
Karadem et al., (2021)	527 Healthcare personnel and hospital staff	Turkey	Anxiety sensitivity physical concerns (<i>Anxiety Sensitivity Index-3: Physical concerns subscale</i>)	Fear of COVID-19 (<i>Fear of COVID-19 Scale</i>)	Predictors of fear of COVID-19: (1) anxiety sensitivity physical concerns ($\beta = .286$)
Longitudinal Design					
Paluszek et al., (2021)	3062 adults; age 18+ years	Canada and United States	Anxiety sensitivity physical concerns (<i>Anxiety Sensitivity Index-3: Physical Concerns subscale</i>) Disgust propensity and sensitivity (<i>Disgust Propensity and Sensitivity Scale-Revised: Propensity and sensitivity subscales</i>)	COVID-19 stress syndrome (<i>COVID-19 Stress Scale</i>) Fear of fomites and the dangers of COVID-19, fear of the socioeconomic ramifications of the pandemic, fear of foreigners who may be infected, checking and reassurance-seeking, traumatic stress symptoms (<i>COVID Stress Scale: DAN, SEC, XEN, CHE, and TSS subscales</i>)	Predictors of COVID-19 stress syndrome: (1) anxiety sensitivity physical concerns ($b = 2.06, se = 0.10$ and $b = 1.81, se = 0.11$; main effect with disgust propensity and sensitivity, respectively) (2) anxiety sensitivity physical concerns*disgust propensity ($b = 0.10, se = 0.02$; interaction effect) (3) anxiety sensitivity physical concerns*disgust sensitivity ($b = 0.05, se = 0.02$; interaction effect) Predictors of fear of fomites and the

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Table 1 (continued)

Author	Sample	Country/ Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
					<p>dangers of COVID-19: (1) anxiety sensitivity physical concerns ($b = 0.80, se = 0.05$ and $b = 0.72, se = 0.05$; main effect with disgust propensity and sensitivity, respectively)</p> <p>Predictors of fear of the socioeconomic ramifications of the pandemic: (1) anxiety sensitivity physical concerns ($b = 0.38, se = 0.02$ and $b = 0.33, se = 0.03$; main effect with disgust propensity and sensitivity, respectively)</p> <p>(2) anxiety sensitivity physical concerns*disgust propensity ($b = 0.02, se = < 0.01$; interaction effect)</p> <p>Predictors of fear of foreigners who may be infected: (1) anxiety sensitivity physical concerns ($b = 0.35, se = 0.02$ and $b = 0.30, se = 0.03$; main effect with disgust propensity and sensitivity, respectively)</p> <p>(2) anxiety sensitivity physical concerns*disgust propensity ($b = 0.02, se = < 0.01$; interaction effect)</p> <p>(3) anxiety sensitivity physical concerns*disgust sensitivity ($b = 0.02, se = < 0.01$; interaction effect)</p> <p>Predictors of checking and reassurance-seeking: (1) anxiety sensitivity physical concerns ($b = 0.26, se = 0.02$ and $b = 0.20, se = 0.02$; main effect with disgust propensity and sensitivity, respectively)</p> <p>(2) anxiety sensitivity physical concerns*disgust propensity ($b = 0.02, se = < 0.01$; interaction effect)</p> <p>(3) anxiety sensitivity physical concerns*disgust sensitivity ($b = 0.02, se = < 0.01$; interaction effect)</p> <p>Predictors of traumatic stress symptoms: (1) anxiety sensitivity physical concerns ($b = 0.29, se = 0.02$ and $b = 0.25, se = 0.02$; main effect with disgust propensity and sensitivity, respectively)</p> <p>(2) anxiety sensitivity physical concerns*disgust propensity ($b = 0.03, se = < 0.01$; interaction effect)</p> <p>(3) anxiety sensitivity physical concerns*disgust sensitivity ($b = 0.02, se = < 0.01$; interaction effect)</p> <p>Predictors of max number of single-substance using days: (1) anxiety sensitivity: ($\beta = .05$ and $\beta = .02$; total and direct effect, respectively)</p> <p>(2) anxiety sensitivity through coping with social conditions of the COVID-19 pandemic with substance use ($\beta = .029$; mediation effect)</p> <p>Predictors of total number of different substances used in past 30 days: (1) anxiety sensitivity ($\beta = .06$; total effect)</p> <p>(2) anxiety sensitivity through coping with social conditions of the COVID-19 pandemic with substance use ($\beta = .028$; mediation effect)</p> <p>Predictors of depression: (1) anxiety sensitivity ($\beta = .15$)</p> <p>Predictors of COVID-19 worry: (1) anxiety sensitivity ($\beta = .17$)</p>
Cho et al., (2021)	2120 high school students; age range 16.3–19.0 years	United States	Anxiety sensitivity (18-item Childhood Anxiety Sensitivity Index)	Max number of single-substance using days (Author constructed) Total number of different substances used in past 30 days (Author constructed) Coping with social conditions of the COVID-19 pandemic with substance use (Author constructed)	
Schmidt Morabito et al., 2021	249 adults: age range 18+ years	United States	Anxiety sensitivity (Anxiety Sensitivity Index-3)	Depression (Depression and Anxiety Stress Scales: Depression subscale) COVID-19 worry (COVID-19 Impact Battery: Worry subscale)	

^a In instances where standardized measures of effect sizes were not reported, unstandardized measures of effects and standard errors (if reported) are provided.

^b To aid in brevity, we have only presented significant findings.

attentional control) and adverse mental health symptoms and COVID-19 specific fears. Finally, anxiety sensitivity interacts with other emotional risk factors (e.g., perceived stress) and synergistically amplifies pandemic-related mental health problems. Throughout this body work, it is noteworthy that the anxiety sensitivity findings that have been observed are often evident after adjustment of potential confounding factors (e.g., COVID-19 exposure, anxiety symptoms) and are consistent with the theoretical position that anxiety sensitivity may amplify emotional reactivity to pandemic stress. There is a need for more research in this area (especially with samples of children and adolescents) using advanced next step research methodology (e.g., laboratory models, multimethod protocols), greater exploration of addictive behavior (cf. mental health), and a wider range of sampling on youth as well as underrepresented groups (e.g., minorities).

2.4. Health anxiety

Definition and theoretical basis, relations to behavioral health, and measurement. Health anxiety is a common experience that arises when bodily sensations or changes are believed to be indicative of a serious disease (Deacon & Abramowitz, 2008; Salkovskis, Rimes, Warwick, & Clark, 2002). Individuals with elevated health anxiety experience excessive vigilance or misinterpretation of bodily symptoms leading to fears or concerns related to one's health and wellbeing (Deacon & Abramowitz, 2008; Salkovskis et al., 2002). For example, an individual may experience a benign symptom such as a headache and begin to fear catastrophic outcomes related to this bodily experience (e.g., "My headache is an indicator of a brain tumor"). These fears may lead to maladaptive behaviors that serve to reinforce health anxiety, including reassurance seeking and excessive bodily checking (Asmundson, Abramowitz, Richter, & Whedon, 2010). To some extent, health anxiety can be adaptive as it may motivate warranted treatment-seeking behavior (Asmundson et al., 2010; Taylor, Asmundson, & Hyprochondria, 2004). When characterized by preoccupation and chronic worry, health anxiety can lead to undue personal suffering, impaired social and occupational functioning, and overutilization of general and specialty health care services (Taylor et al., 2004).

There are a number of scientifically grounded measures available to assess the presence and severity of health anxiety, including the Illness Attitude Scale (IAS; Kellner, Abbott, Winslow, & Pathak, 1987), Whiteley Index (WI; Pilowsky, 1967), and Health Anxiety Inventory (HAI; Salkovskis et al., 2002). In addition, shorter versions of the WI (i.e., WI-7; Fink et al., 1999) and the HAI (i.e., SHAI; Salkovskis et al., 2002) are available. Collectively, these measures have demonstrated sound psychometric properties in previous work (Abramowitz, Deacon, & Valentiner, 2007; Fink et al., 1999; Salkovskis et al., 2002; Sirri, Grandi, & Fava, 2008; Welch, Carleton, & Asmundson, 2009). The SHAI, in particular, has gained increasing popularity among clinicians and researchers due to its utility in the assessment of both healthy and physically ill populations (Salkovskis et al., 2002). The SHAI consists of a 14-item version and an 18-item version. The 18-item version taps into Illness Likelihood (14-items) and Negative Consequences/Illness Severity (4-items; Salkovskis et al., 2002) whereas the 14-item SHAI is thought to have two subscales, including an 8-item Thought Intrusions subscale and a 5-item Fear of Illness subscale (Alberts, Sharpe, Kehler, & Hadjistavropoulos, 2011). However, extant work has suggested the utilization of the one-factor 14-item SHAI as a measure of health anxiety (Alberts, Hadjistavropoulos, Jones, & Sharpe, 2013).

Although health anxiety is classified as a somatoform disorder, the mechanisms underlying this construct share features with anxiety disorders (Olatunji, Deacon, & Abramowitz, 2009; Zvolensky, Garey, Shepherd, & Eifert, 2019). Indeed, health anxiety is present in a variety

of anxiety-related disorders (Abramowitz, Olatunji, & Deacon, 2007). For example, individuals with health anxiety tend to experience body vigilance and catastrophic misinterpretation of such somatic cues similar to those with panic disorder (Deacon & Abramowitz, 2008; Rachman, 2012). Overlap with obsessive compulsive-related symptoms are also evident as demonstrated by overestimation of threat followed by reassurance seeking and safety behaviors (Rachman, 2012). Health anxiety also is associated with other mood-related conditions such as depression (Noyes, 2001, pp. 132–160).

Theoretical applicability to pandemic. The negative consequences of health anxiety as it relates to pre-COVID pandemic-related illnesses (e.g., H1N1) has been empirically documented (Wheaton, Abramowitz, Berman, Fabricant, & Olatunji, 2012). Similarly, health anxiety is likely related to behavioral health outcomes in response to the COVID-19 era. For example, health anxiety may increase vigilance to bodily sensations (e.g., coughing, headaches) due to concerns of the potential negative consequences of such symptoms (e.g., being positive for COVID-19). Such heightened awareness and concerns may be associated with greater general anxiety (e.g., worry about the future) and depressive symptoms (e.g., withdrawal from social contexts). Moreover, elevations in health anxiety may be associated with excessive reassurance seeking (e.g., frequent COVID-19 testing), preventative behaviors (e.g., excessive hand washing), and avoidance behaviors (e.g., not leaving home), further perpetuating distress and functional impairment. Bi-directional relations regarding the impact of mental and behavioral health and health anxiety are also noteworthy as individuals experiencing mood- or substance-related somatic symptoms may experience heightened awareness to such sensations as well as the potential negative consequences (e.g., "My coughing may mean I have lung cancer"). Current work as it relates to health anxiety and mental/behavioral outcomes is presented in Table 2 (see supplementary materials) and bi-directional relationships are presented in Table 4 (see supplementary materials).

Cross-sectional and longitudinal studies on health anxiety in terms of mental health and pandemic sequelae. De Pietri and Chiorri (2021) surveyed 660 adults in Italy in a cross-sectional analysis and found greater levels of health anxiety were associated with greater levels of anxiety symptoms. These findings were evident after accounting for a range of sociodemographic factors (e.g., socioeconomic status), stressors (e.g., occupational stress), and mental health (e.g., depressive symptoms). Among health workers and public service providers in Norway ($n = 773$), health anxiety was a significant predictor of posttraumatic stress disorder (PTSD) symptoms in a cross-sectional test even after controlling for a range of theoretically-relevant variables (e.g., burnout, depression; Johnson, Ebrahimi, & Hoffart, 2020). Research has also found small to moderate effect sizes ($sr^2 = 0.04$) for health anxiety on fears related to contamination and illness in a cross-sectional study among a sample of undergraduate students in the U.S. ($n = 608$; Fedorenko, Kibbey, Contrada, & Farris, 2021). Among a large sample of adults in the United Kingdom ($n = 2329$), cross-sectional analysis revealed health anxiety was a significant predictor of stress (Svensson & Elntib, 2021). A small longitudinal study among 12 outpatient adults in Germany found health anxiety levels pre-COVID-19 were predictive of non-COVID-19 anxiety (Sauer, Schmidt, Jungmann, Bailer, & Witthöft, 2022).

Mediation and moderation studies on health anxiety and mental health and addictive behavior. Ștefan et al. (2021) collected data from 236 participants in Romania. Cross-sectional analysis indicated health anxiety was a significant predictor of COVID-19 anxiety. Mediation models revealed that perceived risk (i.e., susceptibility and severity for COVID-19) was a significant mediator in the relationship between health anxiety and COVID-19 anxiety. In a cross-sectional design among a sample of adults in the U.S. ($n = 720$), health anxiety was related to COVID-19 anxiety directly and through the impact of intolerance of

Table 2
Health Anxiety as a Predictor of Mental Health and Substance Use.

Author(s)	Sample	Country/Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
Cross-sectional Design					
Wheaton et al., (2021)	720 adults; age range 18–74 years	United States	Health anxiety (<i>Short Health Anxiety Inventory</i>) Intolerance of uncertainty (<i>Intolerance of Uncertainty Scale-12</i>)	COVID-19 anxiety (<i>COVID-19 Threat Scale</i>)	Predictors of COVID-19 anxiety: (1) health anxiety ($b = 0.52, se = 0.04$ and $b = 0.37, se = 0.04$; direct and total effect, respectively) (2) health anxiety through intolerance of uncertainty ($ab = 0.15, se = 0.02$; mediation effect) Predictors of anxiety: (1) health anxiety ($pr = .13$)
De Pietri and Chiorri (2021)	660 adult personal and work contacts of the authors; age range 18–79 years	Italy	Health anxiety (<i>Health Anxiety Questionnaire</i>)	Anxiety (<i>Beck Anxiety Inventory</i>)	Predictors of PTSD: (1) health anxiety ($pr = .10$)
S.U. Johnson et al., 2020	773 healthcare workers and public service providers; 18+ years	Norway	Health anxiety (<i>Author constructed measure</i>)	PTSD (<i>PTSD Checklist for DSM-5</i>)	
Landi et al., (2020)	944 adults; age range 18–81 years	Italy	Health anxiety (<i>Short Health Anxiety Inventory</i>) Psychological flexibility global, acceptance, diffusion, and committed action (<i>Multidimensional Psychological Flexibility Inventory: Total score and acceptance, diffusion, and committed action subscales</i>)	COVID-19 peritraumatic distress (<i>COVID-19 Peritraumatic Distress Index</i>) Anxiety (<i>General Anxiety Disorder Scale</i>) Depression (<i>Patient Health Questionnaire</i>)	Predictors of COVID-19 peritraumatic distress: (1) health anxiety ($b = 0.73, se = 0.05$ and $b = 0.823, se = 0.049$; direct and total effect with global psychological flexibility, respectively) (2) health anxiety through global psychological flexibility ($ab = 0.090, se = 0.018$; mediation effect) (3) health anxiety through acceptance ($ab = 0.013, se = 0.007$; mediation effect) (4) health anxiety through diffusion ($ab = 0.153, se = 0.027$; mediation effect) (5) health anxiety through committed action ($ab = 0.057, se = 0.018$; mediation effect) Predictors of anxiety: (1) health anxiety ($b = 0.31, se = 0.02$ and $b = 0.342, se = .019$; direct and total effect with global psychological flexibility, respectively) (2) health anxiety through global psychological flexibility ($ab = 0.031, se = 0.018$; mediation effect) (3) health anxiety through acceptance ($ab = 0.005, se = 0.003$; mediation effect) (4) health anxiety through diffusion ($ab = 0.069, se = 0.011$; mediation effect) (5) health anxiety through committed action ($ab = 0.014, se = 0.007$; mediation effect) Predictors of depression: (1) health anxiety ($b = 0.27, se = 0.02$ and $b = 0.310, se = .022$; direct and total effect with global psychological flexibility, respectively) (2) health anxiety through global psychological flexibility ($ab = 0.031, se = 0.007$; mediation effect) (3) health anxiety through acceptance ($ab = 0.007, se = 0.004$; mediation effect) (4) health anxiety through diffusion ($ab = 0.052, se = 0.011$; mediation effect) (5) health anxiety through committed action ($ab = 0.033, se = 0.009$; mediation effect)
Fedorenko et al., (2021)	608 undergraduate students; age 18+ years 500 adults; age range 18–82 years	United States United States	Health anxiety (<i>Short Health Anxiety Inventory</i>) Health anxiety (<i>Short Health Anxiety Inventory</i>)	Contamination/illness fears (<i>Fear of Illness and Virus Evaluation—Adult Report Form</i>) COVID-19 worry (<i>Author constructed measure</i>)	Predictors of contamination/illness fears: (1) health anxiety ($sr^2 = .040$) Predictors of COVID-19 worry: (1) health anxiety

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Table 2 (continued)

Author(s)	Sample	Country/Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
Maxfield and Pituch (2021)			Gathering information (<i>Preparation for Future Care Needs Short Form: Gathering information subscale</i>)		($\beta = .35$; main effect) (2) health anxiety*gathering information ($\beta = -.11$; interaction effect)
Ştefan et al., 2021	236 participants; age range 16–67 years	Romania	Health anxiety (<i>Short Health Anxiety Inventory</i>) Perceived risk (<i>Adapted measure from the Questionnaire Risk Perception of Infectious Disease: Perceived susceptibility and severity subscales</i>)	COVID-19 anxiety (<i>Adapted Version of the State-Trait Anxiety Inventory</i>)	Predictors of COVID-19 anxiety: (1) health anxiety ($\beta = .519$) (2) health anxiety through perceived risk ($ab = 0.072$; mediation effect)
Stuart et al., (2021)	473 undergraduate students; age range 18–62 years	Australia	Health anxiety (<i>Illness Attitude Scale-mean of the worry and bodily preoccupation subscales</i>) Online social connection (<i>Items from an unpublished measure of motivations for internet use</i>) Isolation behaviors (<i>Author constructed measure</i>)	Depression (<i>Depression Anxiety Stress Scales-21</i>)	Predictors of depression: (1) health anxiety ($sr^2 = .0438$; main effect) (2) health anxiety*online social connection ($sr^2 = .0137$; interaction effect) (3) health anxiety*online social connection*isolation behaviors ($sr^2 = .0131$; interaction effect)
Svensson and Elntib (2021)	2329 adults; age range 18–87	United Kingdom	Health Anxiety (<i>Short Health Anxiety Inventory</i>)	Stress (<i>Perceived Stress Scale</i>)	Predictors of stress: (1) health anxiety ($\beta = 1.07$)
Longitudinal Design					
Sauer et al., (2020)	887 adults; age range 18–85 years	Germany	Health anxiety (<i>Short Health Anxiety Inventory</i>)	SARS-CoV-2 related anxiety (<i>Author constructed</i>) SARS-CoV-2 related preventative and reassurance behavior (<i>Author adapted German Questionnaire for Assessing Hypochondriacal Safety Behavior: Preventative and reassurance behavior subscales</i>)	Predictors of SARS-CoV-2 related anxiety: (1) health anxiety*time ($b = 1.10, se = -0.14$; interaction effect) (2) health anxiety*quadratic slope of time ($b = -0.18, se = 0.05$; interaction effect) Predictors of SARS-CoV-2 related preventative behavior: (1) pre COVID-19 health anxiety ($b = 0.06$) (2) health anxiety during the pandemic ($b = 0.15$) Predictors of SARS-CoV-2 related reassurance behavior: (1) health anxiety during the pandemic ($b = 0.14$)
Papp and Kouros (2021)	295 young adult college students; age range 18–21 years	United States	Health anxiety (<i>Short version of the Health Anxiety Inventory</i>)	Negative affect (<i>Positive and Negative Affect Schedule-Expanded Form</i>)	Predictors of negative affect: (1) health anxiety*within person change in adjustment ($b = 0.09, se = 0.03$; interaction effect)
Hoffart, Johnson, and Ebrahimi (2021)	4936 adults; age 18+ years	Norway	Health anxiety (<i>Health Anxiety Inventory</i>)	Loneliness (<i>UCLA Loneliness Scale-8</i>)	Predictors of loneliness: (1) health anxiety*time ($b = 0.12, se = 0.03$)
Sauer et al., (2022)	12 outpatient adults; age range 24–67	Germany	Health anxiety (<i>Whiteley-Index</i>)	SARS-CoV-2 anxiety (<i>Author constructed</i>) Non-COVID-19 anxiety (<i>Author constructed</i>)	Predictors of non-COVID-19 anxiety: (1) health anxiety pre-COVID-19 ($b = 0.29, se = 0.09$)

^a In instances where standardized measures of effect sizes were not reported, unstandardized measures of effects and standard errors (if reported) are provided.

^b To aid in brevity, we have only presented significant findings.

uncertainty (Wheaton, Messner, & Marks, 2021). In another cross-sectional study by Landi, Pakenham, Boccolini, Grandi, and Tosani (2020), 944 Italian adults completed an online survey regarding mental health during a mandatory lockdown. Results revealed trait health anxiety was directly and indirectly related to peritraumatic distress, anxiety, and depression through psychological flexibility. Mediation models were also evidenced for the effects of trait health anxiety on outcomes through psychological flexibility subscales, including acceptance, diffusion, and committed action.

A cross-sectional study among 500 adults in the U.S. found greater health anxiety was directly related to COVID-19 worry and served as a moderator in the relationship between gathering information about health care planning with COVID-19 worry, such that there was a weaker relationship at higher levels of health anxiety (Maxfield & Pituch, 2021). Among undergraduates in Australia ($n = 473$), there was evidence of a main effect of health anxiety in predicting depression as well as a significant interaction between health anxiety and online social

connection and a three-way interaction (health anxiety x online social connection x isolation behaviors) in predicting depression in a cross-sectional study (Stuart, O'Donnell, O'Donnell, Scott, & Barber, 2021).

Prospective investigations further support the role of health anxiety for poorer mental health. Sauer, Jungmann, and Witthöft (2020) conducted a study among a large sample of adults in Germany ($n = 887$) and found SARS-CoV-2 related anxiety intensified across time with increasing levels of health anxiety. Moreover, pre-pandemic health anxiety revealed small to medium effects on SARS-CoV-2 anxiety over time and the course of the anxiety became steeper until March 2020 in which the regression began to flatten. Pre-pandemic health anxiety was also predictive of SARS-CoV-2 related preventative behaviors and health anxiety during the pandemic was predictive of both SARS-CoV-2 related preventative and reassurance behavior. Further longitudinal support is provided through a study conducted by Papp and Kouros, (2021) among 295 young adult college students in the U.S. in which increases in

Table 3
COVID-19 Anxiety, Worry, and Fear as Predictors of Mental Health and Substance Use.

Author(s)	Sample	Country/Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
Cross-sectional Design					
Albery et al., (2021)	298 adults; age range 18–76 years	United Kingdom	COVID-19 anxiety (Coronavirus Anxiety Scale) COVID-19 anxiety syndrome-perseveration (C-19ASS-Perseveration) Health anxiety (Whiteley Index-7)	Anxiety & depression (Patient Health Questionnaire Anxiety and Depression Scale)	Predictors of anxiety & depression: (1) COVID-19 anxiety ($sr^2 = .04$) (2) COVID-19 anxiety syndrome perseveration ($sr^2 = .03$) (3) health anxiety ($sr^2 = .04$)
Hamzehgardeshi et al., (2021)	318 pregnant women recruited from primary healthcare centers	Iran	COVID-19 anxiety (Corona Disease Anxiety Questionnaire)	Pregnancy-related anxiety (Pregnancy Related Anxiety Questionnaire)	Predictors of pregnancy-related anxiety: (1) COVID-19 anxiety ($\beta = .415$, OR = 1.125)
Walecka et al., (2021)	57 firefighting cadets	Poland	COVID-19 anxiety (Author constructed measure)	PTSD (IES-R by Weiss and Marmar)	Predictors of PTSD: (1) COVID-19 anxiety ($\beta = .235$)
Kharshiing et al., (2021)	305 adults; age range 18–78 years	India	COVID-19 anxiety (Author constructed measure)	Quality of life (Brunsviken Brief Quality of Life Scale)	Predictors of quality of life: (1) COVID-19 anxiety ($\beta = -.135$) ^c
Scharmer et al., (2020)	295 undergraduate students	United States	COVID-19 anxiety (Fear of Illness and Virus Evaluation) Intolerance of uncertainty and specific to COVID-19 (Intolerance of Uncertainty Scale-Short Form: Original version and adapted for COVID-19)	Eating disorder symptoms (Eating Disorder Examination-Questionnaire) Compulsive exercise (Compulsive Exercise Test)	Predictors of eating disorder symptoms: (1) COVID-19 anxiety: ($R^2 = .052$) (2) COVID-19 anxiety*intolerance of uncertainty ($R^2 = .027$ and $R^2 = .027$, generally and specific to COVID-19, respectively; interaction effect) Predictors of compulsive exercise: (1) COVID-19 anxiety*intolerance of uncertainty ($R^2 = .051$ and $R^2 = .319$, generally and specific to COVID-19, respectively; interaction effect)
Saravanan et al., (2020)	433 university students	United Arab Emirates	COVID-19 fear (Fear of COVID-19 Scale) COVID-19 anxiety (Coronavirus Anxiety Scale)	Psychological distress (Kessler Psychological Distress Scale)	Predictor of psychological distress: (1) COVID-19 fear (OR = 1.27) (2) COVID-19 anxiety (OR = 2.98)
Faisal et al., (2021)	874 college students; age range 17–38 years	Bangladesh	COVID-19 worry (Author constructed measure)	Generalized anxiety (Generalized Anxiety Disorder Scale-7) Depression (Center for Epidemiologic Studies Depression Scale Revised) Mental health (Mental Health Inventory-5)	Predictors of generalized anxiety: (1) COVID-19 worry ($\beta = .40$) Predictors of depression: (1) COVID-19 worry ($\beta = .32$) Predictors of mental health: (1) COVID-19 worry ($\beta = -.31$)
Ghandour et al., (2020)	1851 individuals among a university community; age range 17–70 years	Palestine	COVID-19 worry (Author constructed measure)	Distress (Author constructed measure) Insecurity (Author constructed measure)	Predictor of distress: (1) COVID-19 worry (OR = 1.77) Predictor of insecurity: (1) COVID-19 worry (OR = 4.3)
Jia et al., (2020)	3097 adults; age 18+ years	United Kingdom	COVID-19 worry (Author constructed measure)	Stress (Perceived Stress Scale) Anxiety (Generalized Anxiety Disorder Scale) Depression (Patient Health Questionnaire)	Predictors of stress: (1) COVID-19 worry ($\beta = .04$ and $\beta = .06$, much of time and most of time, respectively) Predictors of anxiety: (1) COVID-19 worry ($\beta = -.05$, $\beta = .15$, and $\beta = .13$, no worry, much of time, and most of time, respectively) (2) COVID-19 worry ($\beta = 1.07$ and $\beta = 1.06$, much of time and most of time, respectively with anxiety as a binary outcome) Predictors of depression: (1) COVID-19 worry ($\beta = .07$ and $\beta = .05$, much of time and most of time, respectively) (1) COVID-19 worry ($\beta = .38$ and $\beta = .29$, much of time and

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Table 3 (continued)

Author(s)	Sample	Country/Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
Liddell et al., (2021)	56 refugees and asylum seekers; age 18+ years	Australia	COVID-19 worry about infection (COVID-19 Events and Stressors Measure: COVID-19 infection stressor subscale)	Health anxiety (Bodily Preoccupation Scale of the Illness Attitude scale)	most of time, respectively with depression as binary outcome) Predictors of Health Anxiety: (1) COVID-19 worry about infection ($\beta = .17$) ^d
Mayorga, Smit, et al., 2021	209 college students; age range 18–31 years	United States	COVID-19 worry (COVID-19 Worry Index) Loneliness (UCLA Loneliness Scale)	Depression (Depression Anxiety Stress Scales) Anxiety (Depression Anxiety Stress Scales) Stress (Depression Anxiety Stress Scales)	Predictors of depression: (1) COVID-19 worry ($sr^2 = .01$; main effect) (2) loneliness ($sr^2 = .25$; main effect) (3) COVID-19 worry*loneliness ($sr^2 = .02$; interaction effect) Predictors of anxiety: (1) COVID-19 worry ($sr^2 = .04$; main effect) (2) loneliness ($sr^2 = .08$; main effect) (3) COVID-19 worry*loneliness ($sr^2 = .15$; interaction effect) Predictors of stress: (1) COVID-19 worry ($sr^2 = .03$; main effect) (2) loneliness ($sr^2 = .16$; main effect) (3) COVID-19 worry*loneliness ($sr^2 = .02$; interaction effect) Predictors of anxiety: (1) concern or worry about contracting COVID-19 ($b = 0.06, se = 3.75$) (2) concern or worry that their friends or family members would contract COVID-19 ($b = 0.05, se = 3.30$) Predictors of depression: (1) concern or worry about contracting COVID-19 ($b = -0.53, se = 0.15$) Predictors of stress: (1) concern or worry that their friends or family members would contract COVID-19 ($b = 0.75, se = 0.13$) Predictors of depressive symptoms: (1) COVID-19 worry ($\beta = .39$) (2) COVID-19 worry though resilience ($\beta = -.28$; mediation effect) (3) COVID-19 worry through meaning in life ($\beta = -.22$; mediation effect) Predictors of Positive Affect (1) COVID-19 worry ($\beta = -.14$; main effect) (2) COVID-19 worry*problem-focused coping ($\beta=.10$; interaction effect) Predictors of Negative Affect (1) COVID-19 worry ($\beta = .40$; main effect) (2) COVID-19 worry*meaning-focused coping ($\beta= -.09$; interaction effect) (3) COVID-19 worry*social coping ($\beta= .07$; interaction effect) Predictor of anxiety: (1) COVID-19 Worry ($sr^2 = .24$) Predictor of depression: (1) COVID-19 Worry ($sr^2 = .11$) Predictor of alcohol use
Newby et al., (2020)	5071 adults; age 18+ years	Australia	Concern or worry about contracting COVID-19 (Author constructed measure) Concern or worry that their friends or family members would contract COVID-19 (Author constructed measure)	Anxiety (Depression Anxiety Stress Scales) Depression (Depression Anxiety Stress Scales) Stress (Depression Anxiety Stress Scales)	
Yıldırım et al., (2020)	284 young adults; age range 18–57 years	Iraq	COVID-19 worry (Author constructed measure) Resilience (Brief Resilience Scale) Meaning in life (Meaningful Living Measure)	Depressive symptoms (Patient Health Questionnaire-9)	
Saalwirth and Leipold (2021)	692 adults; age range 18–73 years	Germany	COVID-19 worry (Author constructed measure) Problem-focused, social, and meaning-focused, coping (Brief-COPE: Active Coping and Planning items, Instrumental Support, Emotional Support, and Venting items, and Acceptance, Positive Reframing, and Humor items)	Positive and negative affect (Positive and Negative Affect Schedule)	
Vujanovic et al., (2021)	189 first responders; age 18+ years	United States	COVID-19-related worry (COVID-19 Worry Questionnaire)	Anxiety (Overall Anxiety Severity and Impairment Scale) Depression (Overall Depression Severity and Impairment Scale) Alcohol use severity (Mental Health	

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Table 3 (continued)

Author(s)	Sample	Country/Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
				Correlates Questionnaire) PTSD (PTSD Checklist for DSM-5)	severity: (1) COVID-19 Worry ($sr^2 = .03$) Predictor of PTSD: (1) COVID-19 Worry ($sr^2 = .45$)
Buckner et al., (2021)	347 past-month drinking undergraduate students; age 18+ years	United States	Difficulties engaging in goal directed behavior (<i>Difficulties in Emotional Regulation Scale: Goals subscale</i>) COVID-19 worry (<i>COVID-19 Worry Index</i>) Drinking to cope (<i>Author constructed measure</i>)	Estimated blood alcohol content (<i>Daily Drinking Questionnaire</i>)	Predictor of estimated blood alcohol content: (1) difficulties engaging in goal directed behavior through COVID-19 Worry and drinking to cope ($b = 0.002$; $se = .001$)
Shepherd et al., (2021)	219 daily adult combustible cigarette smokers; age range 18–65 years	United States	COVID-19 worry (<i>COVID-19 Worry Index</i>)	COVID-19 coping motives for smoking (<i>Modified Version of the Modified-Drinking Motives Questionnaire-Revised</i>) Perceived barriers for smoking cessation (<i>Barriers for Cessation Scale</i>) Negative mood, somatic symptoms, and harmful consequences abstinence expectancies (<i>Smoking Abstinence Expectancies Questionnaire; Negative mood, somatic symptoms, and harmful consequences subscales</i>)	Predictors of COVID-19 coping motives for smoking: (1) COVID-19 worry ($sr^2 = .074$) Predictors of perceived barriers for smoking cessation: (1) COVID-19 worry ($sr^2 = .027$) Predictors of negative mood abstinence expectancies: (1) COVID-19 worry ($sr^2 = .034$) Predictors of somatic symptoms abstinence expectancies: (1) COVID-19 worry ($sr^2 = .041$) Predictors of harmful consequences abstinence expectancies: (1) COVID-19 worry ($sr^2 = .072$)
Rogers, Shepherd, et al., 2020	160 adults; age range 18–65 years	United States	COVID-19 worry (<i>COVID-19 Worry Index</i>)	Substance use coping motives (<i>Modified Version of the Modified-Drinking Motives Questionnaire-Revised</i>)	Predictors of substance use coping motives: (1) COVID-19 worry ($b = 0.10$, $se = 0.02$)
Johnstone et al., (2021)	104 individuals with rheumatoid arthritis and ankylosing spondylitis; age range 27–85 years	New Zealand	COVID-19 fears (<i>COVID-19 Fears Questionnaire for Chronic Medical Conditions</i>)	Anxiety (<i>The Hospital Anxiety and Depression Scale</i>)	Predictors of anxiety: (1) COVID-19 fears ($\beta = .395$)
Kira et al., (2021)	262 adults; age range 18–73 years	Turkey	COVID-19 fears (<i>COVID-19 Traumatic Stressors Scale: Threat/fear of the present and future infection and death subscale</i>)	PTSD (<i>Posttraumatic Stress Disorder Checklist for DSM-5</i>) Depression (<i>Patient Health Questionnaire-9</i>) Anxiety (<i>Generalized Anxiety Disorder-7</i>)	Predictors of PTSD: (1) COVID-19 fears ($\beta = .20$) Predictors of depression: (1) COVID-19 fears ($\beta = .24$) Predictors of anxiety: (1) COVID-19 fears ($\beta = .31$)
Lim et al., (2021)	421 older adults; age range 60–87 years	Singapore	COVID-19 fears (<i>COVID-19 Fear Inventory</i>)	Anxiety (<i>Short form of the Geriatric Anxiety Inventory</i>)	Predictors of anxiety: (1) COVID-19 fears ($b = .047$)
Matos et al., (2021)	4057 adults; age 18+ years	Argentina, Australia, Brazil, Canada, Chile, China, Columbia, Cyprus, Denmark, France, Great Britain, Greece, Italy, Japan, Mexico, Poland, Portugal, Saudi Arabia, Slovakia, Spain, United States	Fear of contraction (<i>Perceived Coronavirus Risk Scale</i>) Fear of compassion for self, for others, and from others (<i>Fears of Compassion Scale: Self-compassion, compassion for others, and compassion from others subscales</i>)	Depression, anxiety, and stress (<i>Depression, Anxiety and Stress Scale: Depression, anxiety, and stress subscales</i>)	Predictors of depression: (1) fear of contraction ($\beta = .19$, $\beta = .27$, and $\beta = .20$; main effect with fear of compassion for self, fear of compassion for others, and fear of compassion from others) (2) fear of contraction*fear of compassion for self ($\beta = .009$; interaction effect) (3) fear of contraction*fear of compassion from others ($\beta = .009$; interaction effect) Predictors of anxiety: (1) fear of contraction ($\beta = .32$, $\beta = .40$, and $\beta = .33$; main effect with fear of compassion for self, fear of compassion for others, and fear of compassion from others) (2) fear of contraction*fear of compassion for self ($\beta = .013$; interaction effect) (3) fear of contraction*fear of compassion for others ($\beta = .010$; interaction effect) (4) fear of contraction*fear of

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Table 3 (continued)

Author(s)	Sample	Country/Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
					compassion from others ($\beta = .013$; interaction effect) Predictors of stress: (1) fear of contraction ($\beta = .35$, $\beta = .40$, and $\beta = .35$ main effect with fear of compassion for self, fear of compassion for others, and fear of compassion from others) (2) fear of contraction* <i>fear of compassion for self</i> ($\beta = .008$; interaction effect) (3) fear of contraction* <i>fear of compassion from others</i> ($\beta = .008$; interaction effect) Predictors of anxiety: (1) fear of contracting COVID-19 at work (OR = 2.23) Predictors of psychological distress (1) COVID-19 fear (OR = 1.18) (2) COVID-19 anxiety (OR = 2.60) Predictors of health anxiety: (1) COVID-19 fears through intolerance of uncertainty ($\beta = .394$; mediation effect) (2) COVID-19 fears through positive beliefs about worry ($\beta = .191$; mediation effect) (3) COVID-19 fears through negative beliefs about thoughts concerning uncontrollability and danger ($\beta = .534$; mediation effect) (4) COVID-19 fears through cognitive confidence ($\beta = .332$; mediation effect) (5) COVID-19 fears through beliefs about the need to control thoughts ($\beta = .394$; mediation effect) (6) COVID-19 fears through emotion regulation expressive suppression ($\beta = .274$; mediation effect)
Mattila et al., (2021)	10,425 hospital health care staff; age 18+ years	Finland	Fear of contracting COVID-19 at work (<i>Author constructed measure</i>)	Anxiety (<i>Generalized Anxiety Disorder 7-item scale</i>)	
Saravanan and Mahmoud (2021)	1053 adults: 18+ years	United Arab Emirates	COVID-19 fear (<i>Fear of COVID-19 Scale</i>) COVID-19 anxiety (<i>Coronavirus Anxiety Scale</i>)	Psychological distress (<i>Kessler Psychological Distress Scale</i>)	
Akbari et al., (2021)	541 adults with a family member infected with COVID-19; age range 23–78 years	Tehran	COVID-19 fears (<i>Fear of COVID-19 Scale</i>) Intolerance of uncertainty (<i>Intolerance of Uncertainty Scale</i>) Metacognitions positive beliefs about worry, negative beliefs about thoughts concerning uncontrollability and danger, cognitive confidence, and beliefs about the need to control thoughts (<i>Metacognitions Questionnaire 30</i> ; <i>Positive beliefs about worry</i> , <i>negative beliefs about thoughts concerning uncontrollability and danger</i> , <i>cognitive confidence</i> , and <i>beliefs about the need to control thoughts subscales</i>) Emotion regulation-expressive suppression (<i>Emotion Regulation Questionnaire: Expressive suppression subscale</i>)	Health anxiety (<i>Short Health Anxiety Inventory</i>)	
Wu et al., (2021)	694 adults; age range 19–31 years	Iran	COVID-19 anxiety (<i>Coronavirus Anxiety Scale</i>) COVID-19 fear (<i>Fear of COVID-19 Scale</i>) Intolerance of uncertainty (<i>Intolerance of Uncertainty Scale</i>) Anxiety sensitivity (<i>Anxiety Sensitivity Index-3</i>)	Cyberchondria (<i>Cyberchondria Severity Scale–Short Form</i>)	Predictors of cyberchondria: (1) COVID-19 anxiety through intolerance of uncertainty ($\beta = .06$; mediation effect) (2) COVID-19 fear through intolerance of uncertainty ($\beta = .06$; mediation effect) (3) COVID-19 anxiety through anxiety sensitivity ($\beta = .02$; mediation effect) (4) COVID-19 fear through anxiety sensitivity ($\beta = .04$; mediation effect)
Gold et al., (2021)	103 self-reported daily cigarette smokers; age range 21–63 years	United States	COVID-19 fears (<i>Fear of Coronavirus-19 Scale</i>)	Greater motivation to quit smoking (<i>Author constructed measure</i>) Less cigarette smoking in the last 28 days (<i>Author constructed measure</i>)	Predictors of greater motivation to quit smoking: (1) COVID-19 fears ($\beta = .29$; main effect) Predictors of less cigarette smoking in the last 28 days: (1) COVID-19 fears (OR = 1.14; main effect)
Nikčević et al., 2021	502 adults; age range 20–77 years	United States	COVID-19 anxiety (<i>Coronavirus Anxiety Scale</i>) COVID-19 anxiety syndrome (<i>COVID-19 Anxiety Syndrome Scale</i>)	Anxiety and Depressive Symptoms (<i>Patient Health Questionnaire Anxiety and Depression Scale</i>)	Predictors of greater anxiety and depressive symptoms: (1) COVID-19 anxiety ($\beta = .45$) (2) COVID-19 anxiety syndrome

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Table 3 (continued)

Author(s)	Sample	Country/Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
Longitudinal Design Kleiman et al., (2020)	140 college students; age range 18.44–33.23 years	United States	Health anxiety (<i>Whiteley Index-7</i>) COVID-19 Anxiety (<i>Author constructed</i>)	Anxiety (<i>EMA</i>) Sadness (<i>EMA</i>) Desire to use alcohol (<i>EMA</i>) Desire to use drugs (<i>EMA</i>)	($\beta = .10$) (3) Health anxiety ($\beta = .39$) Predictors of anxiety: (1) COVID-19 anxiety ($\beta = .055$ and $\beta = .033$, contemporaneous and temporal, respectively) Predictors of sadness: (1) COVID-19 anxiety ($\beta = .054$ and $\beta = .035$, contemporaneous and temporal, respectively) Predictor of Desire to Use Alcohol: (1) COVID-19 anxiety ($\beta = .037$ and $\beta = .023$, contemporaneous and temporal, respectively) Predictor of Desire to Use Drugs: (1) COVID-19 anxiety ($\beta = .019$: contemporaneous) No significant findings were evident to report
Sharma et al., (2021)	240 patients with a primary diagnosis of OCD who were on regular follow-up at a tertiary care specialty OCD clinic	India	COVID-related anxiety (<i>COVID-Threat Scale</i>)	OCD relapse (<i>Yale-Brown Obsessive- Compulsive Scale and the Clinical Global Impression–Improvement scale</i>)	Predictors of depression at timepoint 3: (1) COVID-19 fears ($\beta = .13$ and $\beta = .13$ at timepoint 2 and timepoint 3, respectively) Predictors of anxiety at timepoint 3: (1) COVID-19 fears ($\beta = .13$ and $\beta = .15$ at timepoint 2 and timepoint 3, respectively) Predictors of perceived stress at timepoint 3: (1) COVID-19 fears ($\beta = .16$ at timepoint 3) Predictors of personal suffering at timepoint 3: (1) COVID-19 fears ($\beta = .13$ at timepoint 3) Predictors of sleep disturbances: (1) COVID-19 fears ($R^2 = .252$) Predictors of subjective sleep quality: (1) COVID-19 fears ($R^2 = .416$) Predictors of subjective daytime sleepiness: (1) COVID-19 fears ($R^2 = .388$)
Davis et al., (2021)	302 adults; age 18+ years	United States	COVID-19 fears (<i>Ebola Fear Inventory adapted for COVID- 19</i>)	Depression (<i>Patient Health Questionnaire–9</i>) Anxiety (<i>Generalized Anxiety Disorder–7</i>) Perceived stress (<i>Perceived Stress Scale–10</i>) Personal suffering (<i>Personal Suffering Assessment</i>)	
Fellendorf et al., (2021)	20 BD individuals; age 18+ years	Austria	COVID-19 fears (<i>Author constructed measure</i>)	Sleep disturbances global, subjective sleep quality, and daytime sleepiness (<i>Pittsburgh Sleep Quality Index: Total score and subjective sleep quality and daytime sleepiness subscales</i>)	

^a In instances where standardized measures of effect sizes were not reported, unstandardized measures of effects and standard errors (if reported) are provided.

^b To aid in brevity, we have only presented significant findings.

^c Marginally significant findings ($p = .051$).

^d Other findings were reported that did not reach significance due to a Bonferroni correction ($p < .0125$).

negative affect in daily life was significantly higher among individuals reporting greater levels of health anxiety compared to those with lower levels of health anxiety. Finally, among a large sample of adults in Norway ($n = 4936$) health anxiety at time-point one (period of three weeks after the implementation of strict social distancing protocols in Norway) was predictive of less reduction in loneliness over time.

Impact of mental health and addictive behavior on health anxiety. Research has also highlighted the bi-directional relations between health anxiety and mental health outcomes. For example, Kızılkurt (2021) examined the cross-sectional impact of hopelessness and perceptions of self (a psychological resilience factor) in predicting health anxiety among a large sample of adults in Turkey ($n = 1046$). Greater hopelessness and lower perceptions of self were predictive of greater

health anxiety. In a cross-sectional analysis among 169 full-time hospital staff in Iran, both trait and state anxiety were significant predictors of health anxiety even after controlling for factors such as being a frontline worker and being in close contact with an infected person (Shayganfarid, Mahdavi, Haghghi, Sadeghi-Bahmani, & Brand, 2021).

Summary of existing work. The role of health anxiety on mental health outcomes during the pandemic has gained increasing attention. There are several strengths to the current research, including the diverse samples of participants being studied, relative consistency in measurement/assessment of health anxiety, large sample sizes in many of the studies, and a diverse array of mental health variables measured. In terms of main effects, there is initial evidence that health anxiety is related to poorer mental health during the pandemic. Other research has

Table 4

Mental Health and Substance use as Predictors of COVID-19 Health Anxiety and COVID-19 Related Anxiety, Worry, and Fear.

Author(s)	Sample	Country/Region	Predictor Construct(s) (Measure)	Criterion Construct(s) (Measure)	Findings ^{a,b}
Cross-Sectional Design					
Kazan Kizilkurt, Yilmaz, Noyan, & Dilbaz, 2021	1046 adults; age range 18–65 years	Turkey	Hopelessness (<i>Beck Hopelessness Scale</i>) Perceptions of self (<i>The Resilience Scale for Adults: Perceptions of self-subscale</i>)	Health anxiety (<i>Health Anxiety Scale</i>)	Predictors of health anxiety: (1) hopelessness ($\beta = .14$) (2) perceptions of self ($\beta = -.31$)
Shayganfard et al., (2021)	169 Full-time hospital staff; age 18+ years	Iran	State and trait anxiety (<i>State-Trait Anxiety Inventory</i>)	Health anxiety (<i>Health Anxiety Inventory</i>)	Predictors of health anxiety: (1) state anxiety ($\beta = .260$) (2) trait Anxiety ($\beta = .363$)
Hasratian et al., (2021)	175 undergraduate students; age range 18–32 years	United States	Propensity to experience panic (<i>Inventory of Depression and Anxiety Symptoms-Panic subscale</i>)	COVID-19 fear (<i>Fear of COVID-19 Scale</i>)	Predictors of COVID-19 fear: (1) propensity to experience panic ($sr^2 = .035$)
Elhai et al., (2020)	908 Chinese residents; age range 17–64 years	China	Anxiety (<i>Depression anxiety stress scale-21</i>)	COVID-19 anxiety (<i>Generalized anxiety disorder scale-7 adapted for COVID-19</i>)	Predictors of COVID-19 anxiety: (1) anxiety ($\beta = .81$)
Longitudinal Designs					
Savolainen et al., (2021)	1308 workers; age range 18–66 years	Finland	Psychological loneliness (<i>Revised UCLA Loneliness scale</i>) Psychological distress (<i>12-item General Health Questionnaire</i>) Technostress (<i>Author constructed measure</i>) Neuroticism (<i>Big Five Inventory-Short: Neuroticism subscale</i>)	COVID -19 anxiety (<i>Spielberger State-Trait Anxiety Inventory adapted for COVID-19</i>)	Predictors of COVID -19 anxiety: (1) psychological loneliness ($\beta = .11$) (2) psychological distress ($\beta = .17$ and $\beta = .16$; cross-sectional and longitudinally, respectively) (3) technostress ($\beta = .17$ and $\beta = .09$, cross-sectional and longitudinally, respectively) (4) neuroticism ($\beta = .17$)
Z. Wang et al., 2021	222 adults; age 18+ years	China	Subjective well-being (<i>General Well-Being Schedule</i>)	COVID-19 anxiety (<i>Self-check and Self-inspect Scale for COVID-19 Anxiety</i>)	Predictors of COVID-19 anxiety: (1) subjective wellbeing at T0 ($\beta = -.38$; T1 COVID-19 anxiety) (2) subjective wellbeing at T1 ($\beta = -.27$; T2 COVID-19 anxiety)

^a In instances where standardized measures of effect sizes were not reported, unstandardized measures of effects and standard errors (if reported) are provided.

^b To aid in brevity, we have only presented significant findings.

documented that psychological processes (e.g., psychological flexibility, intolerance of uncertainty) mediate the association between health anxiety and poorer mental health. Additionally, some evidence suggests that health anxiety interacts with health behavior (e.g., internet use) in terms of mental health, although there are too limited of studies to draw robust conclusions at the present time. Further, some studies have begun to highlight that there are bi-directional relations between individual differences in mental health and addictive behavior and greater risk for greater levels of health anxiety. Throughout existing work, many of the health anxiety effects were observed after adjusting for other variables, such as sociodemographic factors (e.g., socioeconomic status) and other mental health variables (e.g., depressive and anxiety symptoms).

2.5. COVID-19 anxiety, worry, and fear

Definition and theoretical basis, relations to behavioral health, and measurement. Scholars have sought to characterize several anxiety-related COVID-19 specific constructs during the pandemic given the natural threat imposed by this event. This work has involved separate foci, different approaches to measurement, and reflects related, but distinct, types of anxiety-related processes. This body of research has been oriented in three ways, including research on fear, anxiety, and worry. This type of approach is indicative of the differences inherent to these emotional states. Fear is an emotional reaction to a specific, identifiable, and immediate threat, such as COVID-19 exposure and illness (Rachman, 2004). In contrast, anxiety is a future-oriented affective state whereby the source of threat is more diffuse (e.g., potential virus exposure in a crowded room or plane; White, Ratcliff, Vasey, & McKoon, 2010). Finally, worry reflects primarily cognitive processes about future events wherein the outcomes are uncertain (in contrast to rumination where the content is oriented to the past; Watkins, Moulds, & Mackintosh, 2005); worry can be general or specific (e.g., "Will I die if

get put on a ventilator due to COVID-19 acquisition?"; Borkovec, Alcaine, & Behar, 2004).

To assess arising symptoms specific to COVID-19 researchers began to generate assessments that tap into specific, fears, worries, and anxiety related to the current pandemic. Specifically, fears related to COVID-19 may include an assessment of anxiety-related symptoms (e.g., heart palpitations, sweating) and fears induced in response to COVID-19 related thoughts and events (Ahorsu et al., 2020). COVID-19 anxiety captures the experience of anxiety-related symptoms in response to COVID-19 (e.g., avoidance, sleep difficulties; Chandu, Pachava, Vadapalli, & Marella, 2020). Measures of worry tap into worry across a variety of domains, including health status, social relationships, and finances (Zvolensky et al., 2020). Frequently used measures include the Fear of COVID-19 Scale (Ahorsu et al., 2020), COVID-19 Anxiety Scale (Chandu et al., 2020), and COVID-19 Worry Index (Zvolensky et al., 2020). Although work in this area is still emerging, many scales have been translated into various languages, administered across countries, and demonstrated strong psychometric properties (Ahorsu et al., 2020; Chandu et al., 2020; Lin et al., 2021).

Anxiety-related processes anchored to previous pandemics (e.g., swine flu) have emerged as significant predictors of poor outcomes (Rubin, Amlôt, Page, & Wessely, 2009). For example, work has found swine flu-specific anxiety was associated with higher levels of avoidance behaviors (Rubin et al., 2009). Moreover, pre-existing mental health problems have been found to predict pandemic specific fears, highlighting potential bi-directional relations (Brand, McKay, Wheaton, & Abramowitz, 2013). As such, the impact of COVID-19 specific processes (e.g., fear, anxiety, worry) may demonstrate similar findings and further investigation into the relations between these constructs and mental and behavioral outcomes is warranted.

Theoretical applicability to pandemic. COVID-19 anxiety, fear, and worry have warranted a large degree of attention due to its theorized

impact on behavioral and mental health during the pandemic. Theoretically, individuals who experience elevated COVID-19 anxiety, fear, or worry may experience poorer mental health outcomes due to insufficient coping skills in response to unexpected changes related to the current pandemic and associated health protocols. For example, an individual with increased fear related to COVID-19 may engage in high levels of isolation behaviors and withdrawal from others contributing to depressive symptoms. Moreover, worry or concerns related to COVID-19 may elicit increased tension and difficulty concentrating, among other anxiety-related symptoms. Additionally, increased attention regarding the impact of COVID-specific constructs on substance use is warranted as individuals may be under increased stress in the absence of adaptive coping (e.g., visiting friends, going to the gym). Bi-directional relationships between mental health/substance use and COVID-19 anxiety, fear, and worry are likely relevant as individuals with propensity to experience poor mental health and maladaptive coping may be particularly vulnerable to the development of COVID-19 specific symptoms. Studies examining the impact of COVID-19 specific constructs and mental health can be found in [Table 3](#) (see supplementary materials) and bi-directional relations can be found in [Table 4](#) (see supplementary materials).

Cross-sectional and longitudinal studies on COVID-19 fear, anxiety, and worry in terms of mental health and addictive behavior. Among health care providers in Finland ($n = 10,425$), cross-sectional analysis indicated greater fear of contracting COVID-19 was associated with greater anxiety ([Mattila et al., 2021](#)). Similarly, in a cross-sectional study among older adults in Singapore ($n = 421$), increased COVID-19 fears was related to greater anxiety symptoms ([Lim, Yap, Mahendran, & Yu, 2021](#)). In a sample of adults from the United Arab Emirates ($n = 1053$), COVID-19 fear and COVID-19 anxiety predicted increased psychological distress in a cross-sectional analysis ([Saravanan & Mahmoud, 2021](#)). In a cross-sectional study among 262 adults in Turkey, a direct link between COVID-19 fears and more severe symptoms of anxiety, depression, and PTSD symptoms was evident ([Kira et al., 2021](#)). [Johnstone et al. \(2021\)](#) also reported a significant relation between COVID-19 fear and more severe anxiety in a cross-sectional analysis of 104 individuals with rheumatoid arthritis and ankylosing spondylitis in New Zealand.

[Rogers, Shepherd, Garey, and Zvolensky \(2020\)](#) found that increased COVID-19 worry was related to stronger substance use coping motives in a cross-sectional analysis among 160 adults in the U.S.. Among smokers in the U.S. ($n = 219$), [Shepherd et al., \(2021\)](#) reported that, in a cross-sectional analysis, COVID-19 worry was related to increased, coping motives for smoking, perceived barriers for cessation, and greater expectancies for negative effects following abstinence. Cross-sectional work among 103 cigarette smokers in the U.S. found that higher COVID-19 fears was related to increased motivation to quit and greater cigarette reduction in the past month ([Gold et al., 2021](#)).

[Albery et al., \(2021\)](#) examined cross-sectional relations between health anxiety, COVID-19 anxiety, and COVID-19 anxiety syndrome-perseveration with anxiety/depressive symptoms among 298 adults in the United Kingdom and found that all three outcomes were significant predictors of anxiety/depressive symptoms even after controlling demographics (age, gender), personality domains, vaccination status, and being close to someone who died from COVID-19. [Hamzehgardeshi, Omidvar, Amoli, and Firouzbakht \(2021\)](#) examined COVID-19 anxiety and pregnancy-related anxiety among 318 pregnant women at a primary healthcare center in Iran and found COVID-19 anxiety was a significant predictor of increased odds of pregnancy-related anxiety and linearly increased pregnancy-related anxiety. Among a sample of 57 firefighting cadets hospitalized in a COVID-19 isolation room in Poland, COVID-19 anxiety² was a

significant predictor of PTSD symptoms at a cross-sectional level controlling for depressive symptoms ([Walecka et al., 2021](#)).

In a cross-sectional analysis of 305 adults in India, COVID-19 anxiety was a marginally significant predictor of lower quality of life ([Kharshing et al., 2021](#)). [Saravanan, Mahmoud, Elshami, and Taha \(2020\)](#) examined cross-sectional relationships between COVID-19 anxiety and fear and psychological distress among 433 university students in the United Arab Emirates and found having COVID-19 fear and anxiety increased the odds of experiencing psychological distress. College students in Bangladesh ($N = 874$) were surveyed and COVID-19 worry significantly predicted anxiety, depression, and mental health status ([Faisal, Jobe, Ahmed, & Sharker, 2021](#)). Cross-sectional analysis of 1851 individuals at a university community in Palestine revealed COVID-19 worry was strongly associated with both distress and insecurity in that individuals who experienced high levels of worry were almost twice as likely to report moderate to high insecurity ([Ghandour et al., 2020](#)). [Jia et al. \(2020\)](#) evaluated 3097 adults in the United Kingdom in a cross-sectional study and found that COVID-19 worry (“much of the time” and “most of the time”) was associated with greater levels of anxiety, depression, and stress. Regarding anxiety symptoms, “no worry” related to COVID-19 was also inversely related to anxiety.

Among 56 refugee and asylum seekers in Australia, COVID-19 infection stressors (e.g., worry about being infected) was related to health anxiety symptoms at a cross-sectional level ([Liddell et al., 2021](#)). [Newby, O'Moore, Tang, Christensen, and Faasse \(2020\)](#) examined cross-sectional relations between COVID-19 worry and mental health among a large sample of adults from Australia ($n = 5071$) and found worry about contracting COVID-19 was a significant predictor of depression and anxiety whereas worry about a loved one contracting COVID-19 was associated with anxiety and stress. Among a sample of 189 first responders in the U.S., COVID-19 worry was significantly related to anxiety, depressive, and PTSD symptoms at a cross-sectional level controlling for trauma load, years of services, COVID-19 exposure, gender, and medical vulnerability ([Vujanovic, Lebeaut, & Leonard, 2021](#)). Additionally, COVID-19 worry was a significantly and negatively associated with alcohol use severity. Finally, at a cross-sectional level among 502 adults residing in the U.S., health anxiety, COVID-19 anxiety, and COVID-19 anxiety syndrome were significant predictors of anxiety and depressive symptoms ([Nikčević, Marino, Kolubinski, Leach, & Spada, 2021](#)).

Emerging longitudinal research among 140 college students in the U.S. has also found that COVID-19 anxiety is related to worse mental health outcomes, including general anxiety, sadness, and desire to use alcohol at a cross-sectional and longitudinal level and desire to use drugs at a cross-sectional level ([Kleiman, Yeager, Grove, Kellerman, & Kim, 2020](#)). Additional work has supported a link between COVID-19 fear and behavioral health among a community sample of 302 adults in the U.S. Specifically, COVID-19 fear early into the pandemic (i.e., 1-month and 3-month post-pandemic onset) significantly predicted severity of depression and anxiety at 3-months post-pandemic onset ([Davis et al., 2021](#)). COVID-19 fear 3-months post-pandemic onset was also predictive of greater perceived stress and personal suffering 3-months post pandemic onset. COVID-19 fear also predicted poorer sleep outcomes (i.e., sleep disturbances, subjective sleep quality, daytime sleepiness) among 20 adults with bipolar disorder in Austria ([Fellendorf et al., 2021](#)). Despite evidence for the longitudinal relations of COVID-19 emotion response factors on mental health outcomes, [Sharma et al., \(2021\)](#) did not find an effect for COVID-19 anxiety on Obsessive Compulsive Disorder (OCD) relapse among patients with a diagnosis of OCD in India. However, the rate of relapse was low (only 29 of the 136 patients); therefore, this study may have been underpowered to detect an effect.

Mediation and moderation studies on COVID-19 fear, anxiety, and worry with mental health and addictive behavior. Initial work has begun to explore mediation processes for COVID-19 fear, anxiety, and worry.

² Authors also describe this construct as “sense of COVID threat” and “fear of COVID-19.” These terms are synonymous with one another.

For example, among 284 young adults in Iran, COVID-19 worry was related to depressive symptoms directly and through resilience and meaning in life (Yildirim, Arslan, & Aziz, 2020). Similarly, Wu, Nazari, and Griffiths (2021) also found a significant cross-sectional mediational effect for global anxiety sensitivity and intolerance of uncertainty on the independent relations between COVID-19 fear and COVID-19 anxiety with cyberchondria (i.e., anxiety resulting from a health-related search online; Starcevic & Berle, 2013; Starcevic & Berle, 2015) among 649 adults in Iran. Akbari, Spada, Nikčević, and Zamani (2021) reported that among a sample of adults in Tehran ($n = 541$) who had family members infected with COVID-19, cross-sectional analysis revealed several individual risk vulnerabilities, including facets of metacognitions (e.g., positive beliefs about worry, negative beliefs about thoughts concerning uncontrollability and danger, cognitive confidence, and beliefs about the need to control thoughts), intolerance of uncertainty, and expressive suppression (a facet of emotion regulation), mediated the relationship between COVID-19 fear and health anxiety. The cumulative effect of COVID-19 risk factors, including COVID-19 worry and alcohol use motives to cope with the pandemic, served as serial mediators for the relation for greater emotion regulation specific to goal directed behavior and higher estimated Blood Alcohol Level (BAC) levels among 347 college students in the U.S. (Buckner et al., 2021).

Other research has begun to explore moderation models. Among a large sample of international adults ($n = 4057$) fear of contracting COVID-19 was found to be directly related to depression, anxiety and stress (Matos et al., 2021). The relationship was also found to be moderated by fear of compassion for self and from others for all criterion variables. Additionally, fear of compassion for others moderated the relationship between fear of contracting COVID-19 with anxiety. In a sample of 295 undergraduate students in the U.S., COVID-19 anxiety was associated with eating disorder symptoms (Scharmer et al., 2020) and there was a significant interaction between COVID-19 anxiety and intolerance of uncertainty (generally and related to COVID-19) for eating disorder symptoms and compulsive exercise. Mayorga, Smit, et al. (2021) examined cross-sectional direct effects and interactions among 209 college students in the U.S. and found COVID-19 worry was related to depression, anxiety, and stress directly and at higher (but not lower) levels of loneliness. Additionally, in a study among 692 adults in Germany, cross-sectional analysis revealed COVID-19 worry was a significant predictor of positive and negative affect (Saalwirth & Leipold, 2021). Moreover, COVID-19 worry significantly interacted with problem-focused coping to predict positive affect and meaning-focused and social coping to predict negative affect.

Impact of mental health and addictive behavior on COVID-19 fear, anxiety, and worry. Among a sample of 908 adults in China, anxiety symptoms were a significant predictor of COVID-19 anxiety symptoms at a cross-sectional level (Elhai, Yang, McKay, & Asmundson, 2020). In a study among 1308 workers in Finland, several psychological factors predicted COVID-19 anxiety cross-sectionally, including psychological loneliness and distress, technostress, and neuroticism controlling for a variety of other psychological variables such as work exhaustion, conscientiousness, extroversion, agreeableness, and openness (Savolainen, Oksa, Savela, Celuch, & Oksanen, 2021). Longitudinally, increased psychological distress and increased technostress, was associated with higher odds of COVID-19 anxiety. Other longitudinal work conducted by Wang, Luo, et al. (2021); among 222 adults in China found subjective wellbeing pre-pandemic (T0) predicted COVID-19 anxiety at timepoint one (T1) and subjective wellbeing at T1 predicted COVID-19 anxiety at timepoint two (T2). Finally, among 175 undergraduate students in the U.S., COVID-19 fear was significantly predicted by propensity to experience panic attacks (Hasratian, Nordberg, Meuret, & Ritz, 2021).

Summary of existing work. Pandemic-specific constructs have gained scientific attention and support in relation to their impact on mental and behavioral health outcomes. There are several valid assessment measures for these constructs that have been examined on a diverse array of samples from distinct regions of the world. There are several conclusions

that can be drawn from this corpus of work. First, there is evidence that COVID-19 fear, anxiety, and worry are associated with poorer mental health (particularly anxiety-related symptoms), addictive behaviors used to cope with mental health distress, and health concerns. Thus, specific anxiety-related interoceptive concerns spanning fear, anxiety, and worry are important individual difference factors for pandemic behavioral health. Second, work focused on mediation and moderation of COVID-19 fear, anxiety, and worry is relatively limited. However, the available studies have shown that specific thinking styles mediate relations between these constructs and mental and behavioral health. Further, again while limited in overall scope, some studies have documented that COVID-19 constructs interact with other individual difference factors for poorer mental health. Finally, models focused on explaining variability in COVID-19 fear and anxiety have shown trait level individual differences in mood vulnerability play a key role in the severity of such concerns.

3. Theoretical integration for comorbidity between mental health and addictive behavior

Existing pandemic research has thus far been oriented on effects of interoceptive anxiety-related constructs on mental health or addictive behaviors (i.e., in a single or unidimensional model). We believe that the current time period is a critical juncture in the development of this body of research and provides great opportunity to leverage behavioral science in way to maximize the public health impact of such work for the current and future pandemics. For this reason, we offer an integrative theoretical model that can be employed to focus systematic research on interoceptive anxiety-related constructs in terms of both mental health and addictive behaviors (See Fig. 2).

Broadly, the current literature review suggests that non-COVID-19 specific interoceptive anxiety-related processes (e.g., health anxiety and anxiety sensitivity) and pandemic specific anxiety, worry, and fear are related to an amplification of emotional symptoms. There also is emerging evidence of the bidirectionality of such effects. Influenced by this work, the way in which interoceptive sensations related to COVID-19 exposure or stress are interpreted may function in distinct ways. Specifically, when such internal symptoms are perceived as non-threatening, persons are more likely to engage in everyday activities, permitting higher degrees of functioning. When such somatic perturbation is perceived as threatening, there is more opportunity for catastrophic thinking (e.g., "I am going to die because of virus exposure;" "I am losing control over my mind because of the chronic stress and threat of the pandemic"), elevating the intensity of emotional distress and promoting content specific fears (e.g., COVID-19 fear), escape/avoidance behavioral action tendencies, and vigilance to future signs of somatic threat.

Drawing from negative reinforcement models of addiction (McCarthy, Curtin, Piper, & Baker, 2010), such heightened affective disturbance should be related to the propensity to escape and avoid perceived threat. In fact, we have reviewed some work that has begun to document those exact patterns (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Shepherd et al., 2021). In line with negative reinforcement learning (McCarthy et al., 2010), escape and avoidance (addictive) behaviors represent powerful behavioral responses to interoceptive distress (e.g., bodily symptoms, negative affect). When such escape/avoidance behavior is activated and repeatedly employed, there is opportunity for behavioral inhibition (e.g., physical inactivity in response perceived pain- or arousal-inducing activity), somatic heightened awareness, more severe emotional distress, and higher degrees of functional impairment (Vlaeyen & Linton, 2000).

From this perspective, sensitivity to interoceptive threat represents a focal point for behavioral responses to down regulate such internal disturbances. For many addictive prone behaviors (e.g., substance use, eating, internet use), there is further dynamics because withdrawal symptoms quickly emerge following their implementation and

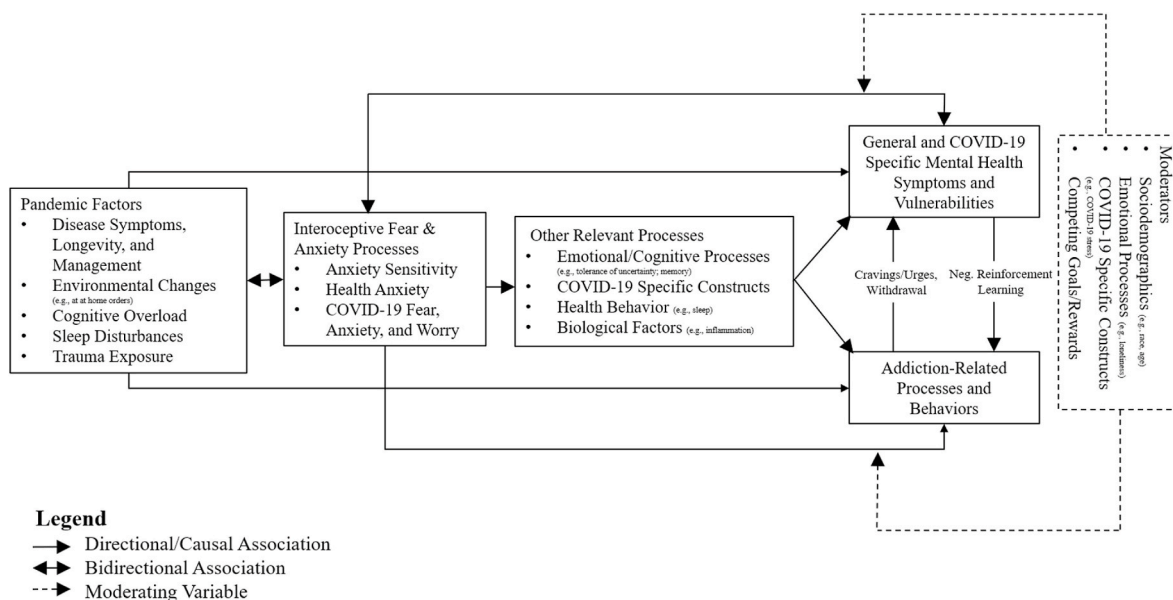


Fig. 2. Integrative Theoretical model for systematic research on interoceptive anxiety-related constructs in terms of mental health and addictive behaviors.

subsequent discontinuation (e.g., not using a substance after regularly doing so will elicit greater internal distress, not using the internet after doing so to distract from internal disturbance; DiFranza et al., 2007). Non-COVID-19 research has documented that such affect-behavior relations can become quickly automatized (Metcalf & Jacobs, 1998; Tiffany, 1990). For example, sensitivity to internal threat (e.g., pandemic-related stress and bodily sensations) predisposes escape/avoidance behaviors, contributing to behavioral routines that serve to regulate interoceptive dysregulation (Paulus, Heggeness, Raines, & Zvolensky, 2021). Thus, there is apt to be dynamic forces linking pandemic-related mental health and addictive behavior co-occurrence. As predictive by negative reinforcement models, regulating interoceptive distress becomes a motivational priority and other behavioral responses become less valued (McCarthy et al., 2010). Persons would be expected to develop cognitive beliefs that addictive behaviors used to down regulate affect (e.g., substance use, eating, internet use) would be associated with anticipated anxiolytic effects, potentially setting the occasion for more ‘emotional benefit’ from their engagement (i.e., greater reinforcement). Because the pandemic has been related to many sources of interoceptive signaling, this time period provides a rich opportunity to develop or engrain existing mental health-addictive behavior comorbidity patterns.

The reviewed general and COVID-19 specific interoceptive anxiety-related constructs represent potential psychological targets for intervention. These constructs maintain a transdiagnostic quality because they are related to numerous symptom presentations and addictive behaviors. For this reason, these constructs can be more efficient at addressing a variety of mental health conditions as well as potential addictive behavior comorbidities compared to separately treating each behavioral health problem. A key implication of this integrated theoretical conceptualization is that intervention programming for general or COVID-19 specific interoceptive anxiety-related factors could simultaneously decrease risk for poorer mental health and addictive behaviors. Future interventions for pandemic-related mental health, addiction, or their comorbidity may orient on and provide psychoeducation about negative reinforcement learning patterns, employ established methods for changing specific constructs (e.g., interoceptive exposure for anxiety sensitivity; Barlow & Craske, 2006; graded pain exposure for pain-related anxiety; de Jong, Vlaeyen, van Eijnsden, Loo, & Onghena, 2012; mindful awareness and acceptance of internal distress; McCallion & Zvolensky, 2015), address beliefs systems about

expectancies that certain behaviors will successfully affect interoceptive disturbances over time, and identify which behavioral strategies work better under what circumstances (e.g., cognitive control may be more effective when distress levels are lower and acceptance strategies may be advantages when emotional distress is elevated; Tice, Bratslavsky, & Baumeister, 2001). These methods may be particularly helpful if carried out prior to trying to make a behavioral change. For example, a person struggling with alcohol misuse and anxiety that were exacerbated by pandemic stress may benefit from psychoeducation behavioral practice (e.g., interoceptive exposure and response training) prior to trying to reduce or change drinking patterns. Indeed, practice and proficiency in the execution of more adaptive strategies for managing mental health and drinking linked to interoceptive anxiety-related concerns may foster greater self-efficacy and skill development and thereby facilitate more opportunity for (mental health and addictive behavior) success.

4. SECTION FOUR: research gaps, clinical implications and future directions

There are several clinical implications and areas for future directions based upon the present review and offered conceptual model. Although we reviewed the available empirical literature on interoceptive anxiety-related constructs in the context of COVID-19 mental health and addictive behaviors, it is important to make explicit that we were limited by the extant data base (an issue that is particularly salient in the youth mental health field wherein fewer COVID-19 related studies are available). There are other interoceptive anxiety-related constructs of potential interest to the current and future pandemics that warrant investment into their role in mental health and addictive behaviors and their co-occurrence, including such constructs as pain-related anxiety (Rogers, Zegel, Tran, Zvolensky, & Vujanovic, 2020), fear of pain (Asmundson, Norton, & Vlaeyen, 2004; Markfelder & Pauli, 2020; Meulders, 2020; Vlaeyen, Crombez, & Linton, 2016) as well as fatigue sensitivity (Manning, Kauffman, Rogers, Garey, & Zvolensky, 2020). With recognition of the growing literature in this domain, we offer a select number of macro-level future directions applicable to the studied constructs in this review but also could be applicable to other interoceptive anxiety-related constructs not yet scientifically explored. Additionally, the present literature is more developed in terms of a focus on mental health relative to addictive behaviors. Therefore, the core conclusions are stronger for making inferences in terms of the role of

interoceptive anxiety-related constructs in mental health rather than addictive behavior. Further, the range of addictive behaviors has been relatively narrow and there is great opportunity to extend research to other behaviors (e.g., other forms of drug use). Finally, most of the literature takes a unidimensional orientation of either focusing on mental health problem(s) or an addictive behavior rather than exploring the relevance to comorbid populations. Given the high rates of comorbidity between mental health and addictive behavior (Garey et al., 2020), it will be important to use theoretical models, such as one offered in the current paper, to guide systematic research on comorbid groups that are more the norm than the exception.

Isolating Causal Relations, Dynamic Interplay, Mediation Processes, and Moderators Existing research is growing, but most of the research focused on interoceptive anxiety-related constructs is limited by the relative paucity of longitudinal work designed to examine the specific models that designate a temporal order of these constructs in terms of mental health and addictive behaviors. Therefore, there is a need to test longitudinal associations between interoceptive anxiety related factors and mental health and addictive behaviors and bi-directional relations in a theory-driven fashion. Studies examining the dynamic interplay and longer-term effects of interoceptive anxiety-related constructs at multiple time points may help to better understand mental health/addictive behavior associations and consequences as it relates to COVID-19 health outcomes (e.g., severity of chronic illness).

Such prospective tests are needed to clarify the temporal precedence of interoceptive anxiety-related constructs in terms of the onset and maintenance of mental health and addictive behaviors. For example, the utilization of time sampling methodology would permit explication of the role of interoceptive anxiety-related concerns in terms of change and potential bi-directional change on mental health symptoms and addictive behaviors over time (Shiffman, 2007). These studies would be most impactful when adjusting for the influence of more generalized variables that represent higher-order emotionality traits (e.g., neuroticism). Also, experimental models for testing interoceptive anxiety-related constructs as factors that affect the experience of acute mental health and addictive behaviors are timely and offer several advantages, including the standardization of stimuli, reliable and valid measurement of multifaceted nature of behavior and cognitive-affective experience, and the ability to demonstrate causal relations. Laboratory-based paradigms have the potential to uncover important theory-based mechanisms (e.g., attentional biases, emotion regulation deficits) that may inform the development of targeted interventions for persons struggling with pandemic related mental health and addictive behaviors.

Although most research to date has examined only a select number of interoceptive anxiety-related constructs and done so by presuming they function as static traits or stable individual differences, it is possible that these factors may operate in a more dynamic fashion. For example, some non-COVID-19 research has found that such constructs maintain active properties in response to perceived threat in real time (Bakhshaie et al., 2020) and within person change can be related to better treatment outcome (Bakhshaie et al., 2016). Additional research is warranted to examine the effects of within-person variability of these constructs in mental health and addictive behaviors, as such work could inform the conceptualization and testing of transdiagnostic treatments for these behavioral health problems in the current and future pandemics.

It is also worthwhile to consider the relative explanatory power of these constructs in the comorbidity of pandemic-related mental health, addictive behavior, and their comorbidity. Although initial research has documented the unique contributions of anxiety sensitivity as well as health anxiety relative to pandemic exposure and stress (Rogers et al., 2021) and some incremental validity of COVID-19 anxiety, worry, and fear for mental health problems relative to health status, COVID-19 exposure and impact, and sociodemographic factors (Mayorga, Smit, et al., 2021), studies designed to explicitly evaluate how these constructs uniquely contribute to covariation between mental health and addictive

behavior are lacking. Future research could also usefully explore the value in testing multiple interoceptive anxiety-related factors in one model (i.e., compared to exploring only one construct), and ultimately, within an intervention addressing pandemic mental health and addictive behavior. In non-COVID-19 research, there has been empirical evidence that certain interoceptive anxiety-related constructs amplify the effects of other such constructs (e.g., anxiety sensitivity may elicit higher levels of fear of pain; Asmundson, 1999). Therefore, isolating how specific constructs affect other factors is important to refining theoretical models and advancing treatment approaches.

There also is a present need to better understand the mediating and moderating factors involved in the observed associations. By focusing more scientific attention on the mechanisms underlying interoceptive anxiety-related constructs and mental health and addictive behaviors, scholars can isolate pathways by which these biobehavioral processes and problems are related. Explication of these pathways promises to clarify how interoceptive anxiety-related constructs vulnerability leads to poor behavioral health, and by extension, offers intervention targets (Little, 2013). Additionally, when treatments are ultimately tested for pandemic-related mental health and addictive disorders that expressly focus on interoceptive concerns, studies of mediation have the potential to provide valuable information regarding how such treatments work and to identify the mechanisms of change within a given treatment (Kazdin, 2007; Kraemer, Wilson, Fairburn, & Agras, 2002). Non-COVID-19 research has suggested several plausible mechanisms linking individual differences in interoceptive anxiety-related concerns to poor behavioral health, including engagement in health-promoting (e.g., exercise, healthy diet, treatment adherence) and health-harming (e.g., poor sleep hygiene; Nabi et al., 2008; Terracciano & Costa, 2004; Wilson & Dishman, 2015; limiting social engagement) behaviors. Moreover, these transdiagnostic factors may be related to impairment in cognitive processes (e.g., executive functions and working memory; Otto et al., 2016), influence immune system functioning (Chapman et al., 2009; Sutin et al., 2010), disrupt emotion regulation processes (Buckner et al., 2021), and potentiate the effects of pandemic and non-pandemic related stress on mental health and addictive behavior by altering the appraisal of such stressors (Zvolensky et al., 2005a, 2005b). Notably, some of these mediators are linked directly to risk of chronic illness such as elevated inflammation (Akiyama et al., 2000; Freund, Orjalo, Desprez, & Campisi, 2010).

The pandemic has highlighted several segments of the general population that are at greater risk for COVID-19 exposure and stress, including but not limited to, certain racial/ethnic minorities, persons of a lower socioeconomic status, individuals who are overweight or having an advanced age, and those with chronic illness (Bhagal, Borg, Jovanovic, & Marusak, 2021; Cai et al., 2020; Gross et al., 2020; Guan et al., 2020; Richardson et al., 2020; Williamson et al., 2020). These sociodemographic and health indicators may serve to highlight subgroups of persons wherein interoceptive anxiety-related concerns have a greater or lesser impact on pandemic related mental health and addictive behaviors. For example, extant work has found that during the pandemic, younger adults (vs. older) experience greater psychological distress although they are less prone to COVID-19 complications (Nikčević et al., 2021; Svensson & Elntib, 2021). The examination of moderators also will inform — in due course — whether a person has greater or lesser benefit from an intervention. Ultimately, identification of subgroups will be an important part in decision making on whether the intervention program is clinically effective or cost-effective. Future research on interoceptive anxiety-related concerns should therefore be designed with sufficient statistical power to detect an interaction (Kamper et al., 2010). It also is important to evaluate the relevance of interoceptive anxiety-related factors as moderators of mental health-addictive behaviors in the context of the pandemic. Initial work has found evidence of such moderation for constructs like anxiety sensitivity for COVID-19 mental health (Manning et al., 2021). Building from this type of work should offer a more targeted approach to prevention and intervention

for these behavioral health problems. For example, it may be more helpful and cost effective to screen for high levels of interoceptive anxiety-related construct and implement targeted or more intensive intervention program for that select group in dealing with mental health and addictive behaviors rather than simply target the general population.

4.1. Intervention programming

Due to the relatively nascent stage of the COVID-19 pandemic, there have been no intervention tests seeking to change (reduce) interoceptive-related anxiety to offset adverse mental and addictive behavior consequences from this global emergency (e.g., functional impairment, quality of life, longer term COVID-19 disease consequences, COVID-stress burden). Such tests are critically important both for theoretical reasons (e.g., helping to establishing causality via randomized clinical trial designs) and the obvious public health impact of targeted or personalized intervention programming. One can imagine interoceptive anxiety-related interventions for persons struggling with elevated levels of pandemic associated anxiety or depression or various addictive behaviors (e.g., smoking, alcohol misuse, overuse of media or internet health information). In non-COVID-19 work, there is a large empirical literature on specific interoceptive anxiety-related constructs in terms of mental health and addictive behavior prevention and treatments. For example, cognitive behavioral methods have been developed and tested in brief and intensive versions via in-person or digitalized approaches for anxiety sensitivity reduction for negative mood states (Capron, Norr, Allan, & Schmidt, 2017; Schmidt, Norr, Allan, Raines, & Capron, 2017), addictive behavior (Zvolensky, Rosenfield, et al., 2018), and the co-occurrence of mental health problems and addictive behaviors (Garey et al., 2021; Paulus et al., 2019, 2021a; Smits et al., 2021). These targeted interventions for interoceptive anxiety-related factors also yield clinically significant effects (Gardenswartz & Craske, 2001; Schmidt et al., 2007). Similar results are available for other interoceptive anxiety-related constructs (LaRowe et al., 2019). Drawing from this research and applying it to pandemic-related mental health and addictive behavior problems will likely be clinically meaningful and efficient, particularly when tailored to COVID-19 issues (e.g., pandemic-related stress). Further, there is apt to be value focused on scaling (up and down) these interventions via digital methods, including first generation approaches that utilize computer interfaces to second-generation phone-based and app-based tools, to reach a larger number of persons at risk for or struggling with mental and addictive disorders related to pandemic exposure and stress (Firth et al., 2017). These are essential ingredients in the larger public health approach to address pandemic-related mental health and addictive behaviors because of the larger segments of these populations that lack access to care, lack access to evidenced based care, and experience numerous obstacles to treatment (e.g., stigma, transportation limitations; Litvin, Abrantes, & Brown, 2013; Marsch, 2012).

Like all approaches to pandemic-related health consequences, this type of intervention work will have to consider healthcare service providers education and knowledge about the role of beliefs systems (in this case, interoceptive anxiety-related concerns) and their role in exacerbating COVID-19 and future pandemic mental health and addictive behaviors and associated clinical correlates (Johnson & Hariharan, 2017). In addition, therapeutic approaches will have to isolate and encourage the dissemination of healthcare service providers willingness and actual delivery of information to their patients about the importance of individual differences in interoceptive (and other) thinking styles as gateways to emotional and addictive behavior problems and link them to appropriate care. It is highly unlikely that persons struggling with pandemic mental health and addictive behavior are aware of the nature of the governing mechanisms underlying their behavioral health problems beyond the general understanding of existential experiences with 'stress' (Brooks et al., 2020). There is clear need to develop empirical

knowledge and understanding about the extent of knowledge and skills sets for addressing transdiagnostic interoceptive anxiety-related factors among healthcare service providers and the degree of training/education in evidenced-based assessment, referral, and treatment that includes a focus on these importance variables.

4.2. Implications for the expression of pandemic-related somatic symptoms, chronic illness, and mortality

The exacerbation of mental health and addictive behaviors is associated with increased risk of somatic symptoms, chronic illness, and mortality in non-COVID-19 (Kauhanen et al., 1999; Morris, Robinson, Andrzejewski, Samuels, & Price, 1993) and emerging COVID-19 specific research (Jeon, Kwon, Park, & Shin, 2021; Nemani et al., 2021). Indeed, persons with mental health problems and addictive behavior such as substance misuse and disorders are apt to be highly vulnerable to physical impairments (e.g., more somatic symptoms) related to the pandemic because of numerous factors, including higher levels of inflammation, damaged cardiovascular and respiratory systems, heightened levels of stress, and compromised immune systems (Licinio & Wong, 1999). These effects are likely related to direct COVID-19 infection, but also non-COVID-19 health status (e.g., exacerbating or increasing the risk for worsening chronic illness; Amick III et al., 2002). Some work that is specific to COVID-19 showcases the risk potential of these behavioral health problems. As one illustrative example, smoking has been related to an increased risk of more severe COVID-19 symptoms (Hopkinson et al., 2021). Further, the ability to cope with somatic symptoms and health problems, in general, will require a chronic demand on coping resources (e.g., medication adherence, social functioning, educational attainment) across a range of stressors and challenges (e.g., effects on personal and family systems; Connor-Smith & Flachsbart, 2007). Moreover, the impact of physical health status and disease has the potential to affect the individual but also the risk potential for future generations (e.g., genetic and epi genetic risk, learning health-specific coping behavior; Compas, Connor-Smith, Saltzman, Thomsen, & Wadsworth, 2001; Peedicayil & Grayson, 2018).

Interoceptive anxiety-related constructs are central to understanding pandemic mental health addictive behaviors, and by extension, many downstream somatic symptoms and disorders tied to these behavioral health problems. The role of these transdiagnostic factors for physical health in the context of the current and future pandemics is presently underrecognized. However, there is robust evidence that several interoceptive anxiety-related constructs, such as anxiety sensitivity (Asmundson, 1999), heart-focused anxiety (Eifert, Zvolensky, & Lejuez, 2001), fear of pain (McNeil et al., 2001), and pain-related anxiety (Rogers, Kauffman, Garey, Asmundson, & Zvolensky, 2020) are important mechanisms in the exacerbation of chronic illnesses via several mechanisms (e.g., avoidance of physical activity, attentional biases, cognitive misinterpretation; Keogh, Dillon, Georgiou, & Hunt, 2001). Further, targeting and changing (improving) these constructs is related to better chronic illness outcomes in controlled research (Leeuw et al., 2007). Some initial COVID-19 specific research has found evidence that certain interoceptive anxiety-related constructs, such as anxiety sensitivity, increase the risk for more severe physical health symptoms (Mayorga, Garey, et al., 2021). However, more research is needed on the role of these transdiagnostic factors for better understanding pandemic related somatic symptoms, chronic illness, and course of COVID-19 infection, particularly among persons with mental health and addictive behavior problems. Drawing from the lessons learned about these constructs in non-COVID-19 chronic illness empirical work over the past two decades, there is good reason to engage in systematic research to explicate the potential of such factors to offset the burden of chronic illness occurring in the current and future pandemics.

4.3. Summary

The public health impact of pandemic-related mental health and addictive behavior problems is substantial and warrants the financial and social investment in research to better understand their etiology, maintenance, and treatment. Moreover, the empirical evidence of significant comorbidity between these conditions, although producing a combined burden upon individuals and systems, also offers insight into the mechanisms underlying their etiology, progression, and maintenance. Interoceptive anxiety-related processes represent psychological mechanisms involved in the amplification of dysregulated affect and a catalyst for negative reinforcement behavior (e.g., using a substance or engaging in a behavior to downregulate affect), theoretically placing persons at risk for pandemic-related clinical problems. Clinical research efforts in these areas may aid in the development of targeted interoceptive-oriented interventions for the respective and combined conditions. We presented a heuristic model, which posits that individual differences in interoceptive anxiety-related concerns may serve as a fertile basis for the escalation of more severe emotional distress and place individuals at greater risk for problematic addictive behaviors in the context of pandemic exposure and stress. Future research in this emerging area has the potential to refine both theory and application with respect to COVID-19 and future pandemics in terms of mental health, addiction, and their comorbid presentation. In addition, future research can expand the proposed heuristic model to other clinically-relevant outcomes (e.g., work disability, quality of life, health-related outcome expectancies).

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Data availability statement

Data are available on request.

CRediT authorship contribution statement

Michael J. Zvolensky: Conceptualization, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Brooke Y. Kauffman:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Software, Writing – original draft, Writing – review & editing. **Lorra Garey:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Software, Writing – original draft, Writing – review & editing. **Andres G. Viana:** Conceptualization, Investigation, Methodology, Project administration, Resources, Software, Writing – review & editing. **Cameron T. Matoska:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Software, Writing – original draft, Writing – review & editing.

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Appendix A. Supplementary data

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