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Psychological distress in healthy, vulnerable, and diseased groups: Neurobiological and psychosocial bases, detection methods, and creative management strategies

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Psychological distress in healthy, vulnerable, and diseased groups: Neurobiological and psychosocial bases, detection methods, and creative management strategies

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Editorial: Psychological distress in healthy, vulnerable, and diseased groups: Neurobiological and psychosocial bases, detection methods, and creative management strategies

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Editorial on the Research Topic
Psychological distress in healthy, vulnerable, and diseased groups: Neurobiological and psychosocial bases, detection methods, and creative management strategies

Psychological distress is described as the non-specific mental symptoms of depression, anxiety, personality traits, and multiple psychological (e.g., burnout), somatic, and behavioral problems. It results from complex dynamics (social, psychological, neurochemical, etc.) associated with overwhelming and sustained stress and painful experiences. The COVID-19-related psychological impact has been widely addressed in this article collection. Nurses are directly involved in COVID-19 care, and two studies have denoted that their physical and mental health may considerably suffer. Alzahrani et al. reported a 63.8 and 68.8% prevalence of depression and anxiety, respectively, among emergency nurses in Saudi Arabia during the COVID-19 pandemic. Significant risk factors associated with anxiety and depression were low physical activity and working in urban areas. Using a purposive sampling approach, Al-Amer et al. interviewed 10 Jordanian nurses from a hospital designated for COVID-19 patients to explore the experience of Arab nurses of caring for COVID-19 patients. The themes generated from the qualitative data uncovered an impact of COVID-19 on nurses' health, unfamiliar work and social environments, and a need to conform to professional standards. The study highlighted specific risks to the physical and mental wellbeing of Arab nurses caring for COVID-19 patients.

Because of pandemic distress, especially among those caring for irreversible and chronic conditions, Ali et al. used data from an online survey of dementia family caregivers to examine the psychometrics of the Depression Anxiety Stress Scale 8-items (DASS-8) relative to two longer distress measures. The DASS-8 demonstrated adequate validity (construct, measurement invariance, convergent, criterion, and discriminant) relative to the DASS-12 and DASS-21. Known-group validity tests revealed greater distress among female caregivers,

the adult children of care recipients, those caring for patients with high dependency in their activities of daily living, and those who received help with care (e.g., from health professionals). The DASS-8 revealed higher distress and strongly correlated with loneliness, suggesting its usability for identifying caregivers with greater proneness to psychopathology.

Because of the failure of lockdowns and traditional protective measures against COVID-19, vaccines have been promoted by the WHO to limit infection transmission, leading to many reported concerns regarding their safety and efficacy in different countries around the world. Based on a nationwide survey in Bangladesh, Alam et al. investigated the psychological effects and associated factors among individuals who received or did not receive COVID-19 vaccines. Consistent with similar studies, vaccinated individuals had significantly lower prevalence rates of psychological distress (36.4 vs. 51.5%), depression (21.1 vs. 37.9%), anxiety (25.1 vs. 44.9%), stress (19.4 vs. 30.4%), PTSD (29.4 vs. 38.3%), insomnia (18.7 vs. 39.4%), and fear symptoms (16.1 vs. 27.5%) than those who were not vaccinated, especially those who were employed or living in Dhaka. Among vaccinated people, living in nuclear families and losing family members or friends because of COVID-19 were associated with greater levels of distress, depression, anxiety, fear, and post-traumatic stress symptomatology.

Harboring large numbers of students and teachers, the school environment has been extensively affected by COVID-19-related closures and the strict emphasis on the use of protective measures, which represented a cause of stress for teachers, students, and families. Răducu and Stănculescu examined the burnout profiles of 330 Romanian kindergarten and primary school teachers and their association with various stressors, including workload, student misbehavior, lack of recognition, and poor colleague relationships. The study uncovered four burnout profiles, with high workload, student misbehavior, and lack of recognition being the main stressors. Better career opportunities, time management, and classroom management could help prevent teacher burnout, especially during the COVID-19 pandemic, which has increased burnout symptoms.

The mental health of university students has also been addressed in many studies. Chen F. et al. studied the psychological mechanisms of English emotion word processing under the semantics–prosody Stroop effect paradigm in quiet and noisy listening environments among Chinese college students with trait depression (TD). Compared with low-TD students, high-TD students displayed a marked lack of sensitivity toward emotions. The Stroop effect influenced emotion word processing automatically, regardless of trait severity or listening conditions. While the speech-shaped noise backdrop had no effect, the participants were more affected by the Stroop effect when doing prosody tasks and recognizing emotions than when performing semantic activities and identifying the valence of English words. The results suggest an emotional processing disadvantage in individuals with high TD and the congruence-induced facilitation effect in the general Stroop effect. In another study, Zhang et al. examined the relationships among several aspects of TD and their relative relevance. The results of a network analysis confirmed that trait anhedonia relates to non-planning and cognitive impulsiveness, whereas trait dysthymia relates to motor impulsiveness, confirming that cognitive impulsiveness is an underlying characteristic of depression susceptibility, and trait dysthymia is a significant component connecting impulsiveness with trait sadness. Anhedonia and dysthymia seem to be distinct components in impulsive personality, and their management may aid the prevention of depression in this population. Moreover, Xu Y. et al. measured intolerance of uncertainty (IU) and electroencephalographic responses to uncertainty in trait-anxious (TA) and non-TA students to investigate whether mitigating anticipatory threat responses is a potential mechanism through which mindfulness may alleviate anxiety. In the predictable and unpredictable threat test, excessive anticipatory responses to unpredictable threats [IU, late positive potential (LPP), and reaction time (RT)] were high among TA students, along with low mindfulness. In uncertain threats, there were significant mediating effects of the LPP amplitude and RT on the relationship between mindfulness and anxiety. Shao et al. examined the factors influencing the effectiveness of online learning among 377 university students. A self-directed learning approach and attitude had a negative effect on the students' internet cognitive fatigue and a positive effect on their flow. Perceived learning ineffectiveness was positively influenced by internet cognitive fatigue and negatively influenced by the flow state. To enhance the effectiveness of online learning, online teachers may need to focus on improving students' self-directed learning awareness, attitude, and approach.

Living alone has been related to poor mental health, but large-scale epidemiological research on the association between living alone and depression and anxiety is scarce. Chen T. Y. et al. evaluated the correlation between living alone and psychiatric illness in a large population-based study. It revealed a statistically significant correlation between the two variables in married but not unmarried subjects. Given that living alone may be a risk factor for psychiatric illness in married individuals, it is important to enhance care delivery to married individuals living alone due to divorce, separation, or the death of their spouse in order to safeguard their physical and mental health. In a related study, Xu R. et al. used data from the Chinese Longitudinal Healthy Longevity Survey to examine the relationship between living arrangements and depressive symptoms among older adults (over 65). Living arrangements significantly correlated with the risk for depressive symptoms, with those living alone or in assisted living institutions expressing a higher risk than those living with household members. However, engaging in outdoor activities played a moderating role and reduced the risk of depression among older adults living in assisted living institutions.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Teachers' Burnout Risk During the COVID-19 Pandemic: Relationships With Socio-Contextual Stress—A Latent Profile Analysis

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The purpose of this cross-sectional study was to identify distinct burnout profiles of teachers and to examine their association with work-related stressors, such as workload, students' misbehavior, classroom resources, professional recognition needs and poor colleague relations, as well as socio-demographic variables. Survey data were collected from 330 kindergarten and primary school teachers (84 males, M_{age} = 38.3, SD = 9.14). The latent profile analysis revealed four distinct profiles. The antecedents of teacher burnout (TB) profiles were the stress generated by workload, students' misbehavior, and low professional recognition. The socio-demographic variables, with the exception of gender, were covariates of the TB profiles. The findings implies that career opportunities prospects, classroom management and time-management programs may be useful in preventing teacher burnout.

Keywords: teacher burnout, work-related stress, psychological profile, COVID-19, online teaching, mixture modeling approach

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INTRODUCTION

In this very difficult time for people worldwide, teachers are one of the most challenged groups of workers (1). Being forced to adapt in a short time to new ways of working that include social distancing in classrooms, hybrid teaching and virtual instructions (2), teachers have reported increased levels of anxiety, difficulties in communication and a lack of administrative support (3). All these new stressors proximal to burnout added to the fear generated by COVID-19, which almost all people have experienced (4). A report to UNESCO (5) emphasized the importance of studying the psychological effects of the pandemic on most challenged workers so that the knowledge gained may be applied to prevent and alleviate the difficulties encountered by them in predicted future waves. In this regard, our purpose is to respond to this call by shedding light on stressors that contribute to teacher burnout (TB) in order to help support and enable teachers to meet the next challenges of the pandemic.

TEACHERS' WORK-RELATED STRESS AND BURNOUT

After decades of research confirming that teaching is a stressful profession (6–8), it has been emphasized that understanding why stress is so pervasive in the field of education can help prevent it (9).

The burnout phenomenon has been conceptualized as a psychological response to prolonged work-related stress that affects one's health and emotional balance (10). The COVID-19 pandemic has affected the social connections of all people, generating new challenges at home and at work (10). In this regard, the socio-contextual burnout proposed by Pietarinen et al. (11) highlights a more social side of teacher burnout and describes three distinct symptoms: (i) exhaustion characterized by a lack of emotional energy and a feeling of being overwhelmed and tired at work; (ii) cynicism represented by detachment from the job in general, as well as from the teaching community and (iii) inadequacy in teacher-pupil interaction. Literature on this particular type of burnout is scarce but very relevant to the current working conditions of teachers.

Extensive previous research on TB has identified several individual and environmental factors that significantly contribute to TB before (12, 13) and during the COVID-19 pandemic (3, 14). Individual factors, such as gender and experience, have been discussed (15, 16). Other individual aspects, such as emotional intelligence (17, 18), personality traits (19, 20) and self-efficacy (14, 21) are also factors that influence TB. In this regard, previous studies have highlighted those seasoned teachers are less likely to experience burnout symptoms compared to younger teachers, while teachers with increased emotional intelligence and self-efficacy but less neurotics are more protected from experiencing burnout symptoms.

Furthermore, the most popular framework that explains the processes involved in professional stress and burnout is Lazarus and Folkman's (22) transactional model. According to this model, the activities undertaken by an individual (cognitive, emotional, behavioral and physiological reactions) to deal with a situation perceived as stressful will or will not allow them to overcome this situation. Additionally, this model emphasizes the importance of the cognitive evaluations that the subject makes of the situation and their own resources (personal and social) and highlights the influence of the individual's attempts to change the situation or themselves through coping strategies. In the educational field, Kyriacou (23) adopted the theoretical conceptualization put forward by Lazarus and Folkman (22) to predict school teachers' reactions. Thus, they defined teacher stress as "the experience by a teacher of negative, unpleasant emotions, such as anger, tension, frustration, depression, which result from a certain aspect of working as a teacher" (23). According to Kyriacou's (24) model of teacher stress, potential stressors are seen as antecedents of teacher stress. The main stressors are physical (e.g., many students in the class) and psychological (e.g., poor colleague relationships). The effect of stressors at work is mediated by coping mechanisms. If coping mechanisms are inadequate, stress occurs. According to the model, teachers' stress is considered to have a negative effect on several dimensions: psychological (e.g., dissatisfaction at work), physiological (e.g., high blood pressure) and behavioral (e.g., absenteeism). Previous studies have examined a wide range of potential variables that have influenced teacher stress, including school environment, classroom and instructional factors (25–28).

Another model introduced to identify precursors of work burnout due to excessive work is the job demands-resources (JD-R) framework (29). In this model, job demands are physical, psychological and social organizational aspects of the job that require physical and/or sustained psychological efforts or skills. Job resources are physical, psychological, social or organizational aspects of the job that are functional in achieving work objectives. These resources are compensatory responses to deficits in meeting demand; they are also recognized as catalysts for growth and development. Stress and burnout result from a subjective mismatch assessed between job demands and resources. A balance of job demands and resources would mean that individuals—in this case, teachers—could successfully fulfill their responsibilities and not experience stress and burnout symptoms. This model has been successfully involved in identifying the resources and job demands that lead to teacher stress and burnout before (30, 31) and during the pandemic (32).

Concerning environmental stressors in the pandemic context, the literature has often discussed organizational factors as important influences on TB. In this regard, time pressure and workload (33, 34), the lack of social and administrative support (9, 35, 36), teaching demands (3) and technostress (37) significantly contribute to TB in the pandemic context. In Romanian settings, before pandemic, as in other countries (19, 31, 38), the work overload and student misbehavior were positively associated with teacher burnout (39), while their low emotional intelligence and high level of neuroticism predicted the onset of burnout symptoms (18). However, the link between stressors and teacher burnout during the pandemic, in a cultural context, has not yet been studied.

In terms of measuring teachers' stressors, Boyle et al. (40) proposed a five-factor model based on teacher stress model (23) that includes workload, students' misbehavior, professional recognition needs, classroom resources and poor colleague relations as main sources of stress for teachers. As far as we know, no previous research has tried to profile TB in relation to stressors in and before a pandemic. Therefore, we examined all dimensions of teachers' stress from Boyle's model and their impact on TB profiles in the pandemic context.

Most of the previous research aimed at profiling TB focused only on clustering it with protective factors, such as self-efficacy, well-being, resilience and coping strategies (16, 41, 42), classroom management and social support (43, 44). Less attention has been paid to identifying those stressors that are the most challenging for teachers and taking into account their predictive role in TB profiles. Therefore, our study goes a step beyond previous studies that identified proactive strategies and other protective factors to emphasize that it is equally important to determine what stressors teachers struggle with during the COVID-19 pandemic.

AIM OF THE STUDY

The main purpose of the current research was to explore how various types of work-related stress among preschool and primary school teachers impact TB risk profiles. More specifically, we first determined whether there were distinct profiles of exhaustion, inadequacy and cynicism that might capture different patterns of TB. Second, we verified antecedents

of profiles, namely various types of teacher stress, such as workload, students' misbehavior, professional recognition needs, classroom resources and poor colleague relations. The research design was developed in the framework of the job demands–resources model of burnout (29) and the transactional model of stress proposed by Lazarus and Folkman (22). The job demands–resources model highlights that high workload or work demands and low levels of resources are associated with job strain. According to the transactional model of stress, when one's perceived ability to cope is exceeded by perceived demands, the stress response intensifies.

Based on previous studies that highlighted burnout symptoms experienced by teachers in the COVID-19 pandemic (3, 16, 42), we determined the first research question (RQ):

(RQ1) Are there different teacher profiles in terms of experienced socio-contextual burnout consisting of exhaustion, cynicism toward the professional community and inadequacy in teacher –pupil interaction during the COVID-19 pandemic?

Furthermore, considering previous studies on the relationship between stressors such as workload (34), professional recognition (8, 45), student misbehavior (38), classroom resources (19), social support (44) and TB, we developed the next question:

(RQ2) Do teachers with the different profiles differ from each other in terms of experienced stressors, such as workload, professional recognition needs, students' misbehavior, classroom resources and poor colleague relations, during the COVID-19 pandemic?

Taking into account the previous study that highlighted the association between socio-demographic variables and TB profiles (16), we determined the last question:

(RQ3) Are socio-demographic variables—that is, gender, teaching level, professional experience and urban or rural teaching environment—covariates of TB profiles?

METHODS

Participants

Our sample included 330 educators (75% women, $M_{age} = 38.3$ years, $SD = 9.14$), of which 108 worked at the preschool level and 222 at the primary school level. Their reported professional experience was less than two years (4.5%), between two and five years (10.9%), between five and 10 years (19.1%), between 10 and 20 years (25.5%) and more than 20 years (40%). Using a convenience sampling method, we selected the teachers from the register of district Teachers Council The total response rate of the e-mail paper survey sent to teachers was 45%. The selection criteria for inclusion in this study were a primary or preschool level of teaching.

Procedure

The current study had a cross-sectional design based on responses to a survey that comprised three sections. The first section included the study details, the informed consent and the guaranteed confidentiality of all data obtained. The second section included participants' socio-demographic information, such as gender, teaching grades, years of professional experience and urban or rural teaching environment. The last section involved reporting the levels of burnout and stress. The study was conducted in accordance with the Declaration of Helsinki and the recommendations and approval by Bucharest University Ethics Committee (no 11/26.04.2021). Data were collected during the 2021 spring break via Google Forms, the questionnaires being sent to teachers by e-mail.

Measures

The Romanian translation of all measures used in the current study was performed according to the recommended forward-backward translation procedures described by Sousa and Rojjanasrirat (46).

The Socio-Contextual Teacher Burnout Inventory (STBI) (11) was used to measure TB. This nine-item scale (sample item: *"With this work pace, I don't think I'll make it to the retiring age"*) employed a Likert scale from 1—completely disagree to 7—completely agree. The established three constructs were teacher exhaustion *(item e.g., "I feel burnt out.")*, cynicism toward the teacher community *(item e.g., "I often feel like an outsider in my work community.")* and inadequacy in the pupil–teacher relationship *(item e.g., The challenging pupils make me question my abilities as a teacher.").* There is currently no study in the literature that indicates a cut-off for this scale. Therefore, according to the study of Pyhältö et al. (16), we considered that as the scores are higher, the burnout level is also higher. More precisely, we considered that depending on the answers given on the Likert scale from 1 to 7, we will have the following thresholds: 1–3—no burnout; 4–6—very low burnout; 7–9—mild burnout; 10–12—moderate burnout; 13–15—high moderate burnout; 16–18—high burnout; 19–21—very high burnout. In our sample, STBI proved very good psychometric properties in terms of: (i) internal consistency ($\omega_{hierarchical} = 0.91$, $\omega_{exhaustionl} = 0.88$, $\omega_{inadequacy} = 0.85$, $\omega_{cynicism} = 0.80$; $CR = 0.94$); (ii) convergent validity (AVE = 0.64); and (iii) construct validity (CFI = 0.97, TLI = 0.95, RMSEA = 0.06, CI [0.04, 0.09], SRMSEA = 0.02, λ_s ranged between 0.57 and 0.86).

The Teacher Stress Inventory (TSI) measures work-related teacher stress (40). This scale comprises 20 items (e.g., "*Level of stress concerning noisy pupils*") and uses a Likert scale from 0—*no stress* to 4—*extreme stress* to assess teachers' stress in five dimensions—workload *(item e.g., "Level of stress concerning to much work to do"*), students' misbehavior *(item e.g., "Level of stress concerning maintaining class discipline."*), professional recognition needs *(item e.g., "Level of stress concerning poor career structure/poor promotion prospects."),* classroom resources *(item e.g., "Level of stress concerning lack of time to spend with individual pupils.")* and poor colleague relations *(item e.g., "Level of stress concerning attitudes and behaviors of other teachers.").* In our sample, TSI proved good psychometric properties in terms of: (i) internal consistency ($\omega_{hierarchical} = 0.92$, $\omega_{profrecognition} = 0.80$, $\omega_{stdbehavior} = 0.88$, $\omega_{workvol} = 0.60$, $\omega_{workresources} = 0.87$, $\omega_{relations} = 0.82$; $CR = 0.94$); (ii) convergent validity (AVE = 0.53); and (iii) construct validity (CFI = 0.95, TLI = 0.93, RMSEA = 0.07, CI [0.05, 0.09], SRMSEA = 0.03, λ_s ranged between 0.59 and 0.83). Socio-demographic variables such as gender, teaching level, professional experience and urban or rural teaching environment were collected.

Data Analysis

Latent profile analysis (LPA) was performed to identify sets of mutually exclusive and exhaustive latent profiles using continuous indicator variables, that is, the three dimensions of TB—exhaustion, inadequacy and cynicism. LPA is a mixture modeling technique by which groups of people are captured based on similarities in their responses to various research variables, in our study the three dimensions of TB. LPA analysis was conducted using Mplus 8.6 software (47). The robust maximum likelihood (RML) estimator was used, as it produces robust standard errors to handle non-normally distributed data. Models with 2–5 classes were considered, each with three indicators, that is, the dimensions of TB. We run Monte Carlo analysis to compute the specific fit indicators for statistical power to detect the correct number of profiles in LPA, as recommended by Tein et al. (48) and Spurk et al. (49). Optimal model selection was based on several information criteria—log likelihood (LL), Akaike information criterion (AIC), Bayesian information criterion (BIC), sample size-adjusted BIC (SSA-BIC) and entropy R^2. Lower values for the AIC, BIC and SSA-BIC indicate a better balance between model fit and parsimony, while higher values for entropy (i.e. > 0.80) indicate better classification utility and class separation. Supplementary tests—an adjusted Lu-Mendell-Rubin likelihood ratio test (aLMR) and a bootstrap likelihood ratio test (BLRT)—were performed in order to compare the subsequent models. A statistically significant test result ($p < 0.05$) indicates that the model with k classes fits the data better than the model with one latent class less, that is, k-1 classes (50). Additionally, solution stability was checked to assure the maximum likelihood solution is replicated using multiple sets of random starting variables. Model identification was evaluated with 1,000 sets of random starting values for all models, 100 iterations and 100 solutions retained for final stage optimization. After identification of the profiles, we testified the predictive role of various types of teacher stress on profile membership using multinomial logistic regression computed with the R3STEP procedure. Baseline-category multinomial logistic regression provides the increase in odds of membership in a target latent profile compared to other profiles for one-unit increases in the predictor, that is, various types of teacher stress. The association between socio-demographic variables—gender, teaching level, professional experience and urban/rural teaching environment—and profile membership was conducted based on multinomial logistic regression with an R3STEP approach.

RESULTS

The descriptive statistics for sociodemographic variables are shown in **Table 1**.

Furthermore, the profile indicators and predictors of profile membership are depicted in **Table 2**.

Latent Profile Solutions

Fit statistics from the LPA models, that is, two-profile to five-profile solutions, are set out in **Table 3**. As can be seen, gradual improvement was observed up to the four-profile solution, and the five-profile solution decreased the quality of the classification.

TABLE 1 | Descriptive statistics for sociodemographic variables.

Variable	Frequency (Valid%) or Mean (*SD*)	
Sociodemographic		
Gender	Male	84 (25.5%)
	Female	246 (74.5%)
Teaching level	Preschool	108 (32.7%)
	Primary school	222 (67.3%)
Professional experience(years)	<2	15 (4.5%)
	2–5 36	(10.9%)
	6–10	63 (19.1%)
	11–20	84 (25.5%)
	>20	132 (40.0%)
Urban/rural environment	Urban	217 (65.8%)
	Rural	113 (34,2%)

TABLE 2 | Profile indicators and predictors of profile membership.

	M (*SD*)	Min	Max	Skewness	Kurtosis
Exhaustion	12.18 (4.51)	3	21	−0.10	−0.80
Inadequacy	9.79 (4.88)	3	21	0.36	−0.90
Cynicism	11.66 (5.31)	3	21	−0.19	−1.24
Stress workload	4.38 (1.99)	0	8	−0.47	−0.40
Stress students' misbehavior	11.64 (5.87)	0	24	−0.04	−0.94
Stress low professional recognition	3.71 (2.06)	0	8	0.04	−0.59
Stress low resources	4.76 (2.41)	0	8	−0.20	−1.06
Stress poor colleagues relations	5.06 (3.05)	0	12	0.21	−0.85

the significant V-L-M-R Likelihood results (<0.5) averaged over replications as indicating that the study had enough power or capacity to correctly recover a four-profile vs. a three-profile solution Although some of the fit indicators—LL, AIC, BIC and SSQ-BIC—had the lowest values for the five-profile solution, entropy was lowest and the best loglikelihood value has been not replicated for the model including five-profile solution. The aLMR value was not significant for the five-profile solution but was significant for the four-profile solution. Consequently, these results lent support for the four-profile solution as the best fitting model for the present study's data. Additionally, in the four-profile model, the average latent profile probabilities for the most likely profile were 0.97, 0.87, 0.94 and 0.91. All were well above the cut-off (> 0.80) recommended by Watson et al. (51).

Four-Profile Model of TB Risk

The model best fitted to our data, the four-profile model of TB risk, is depicted in **Figure 1**, taking into account within-profile item means obtained for each indicator of profile membership, that is exhaustion, inadequacy and cynicism.

Parameter estimates for overall item respectively within-profile item means for the four-profile model are set out in **Table 4**. As can be seen, the first profile, *Low burnout*

TABLE 3 | Model fit information for latent profile analysis.

No. of profiles	Free parameters	LL	AIC	BIC	SSA-BIC	Entropy	aLMR	BLRT
2	10	−2704.76	5429.52	5467.51	5435.79	0.880	518.40 (0.00)	0.00
3	14	−2588.96	5205.92	5259.10	5214.69	0.897	222.03 (0.00)	0.00
4	**18**	**−2561.22**	**5158.45**	**5226.83**	**5169.74**	**0.883**	**53.17 (0.00)**	**0.00**
5	22	−2531.01	5105.03	5189.61	5119.83	0.879	57.92 (0.15)	0.00

Bold indicates best fitted model. LL, log likelihood; AIC, Akaike information criterion; BIC, Bayesian information criterion; SSA-BIC, sample size adjusted BIC; aLMR, adjusted Lu-Mendell-Rubin likelihood ratio test; BLRT, bootstrapped likelihood ratio test.

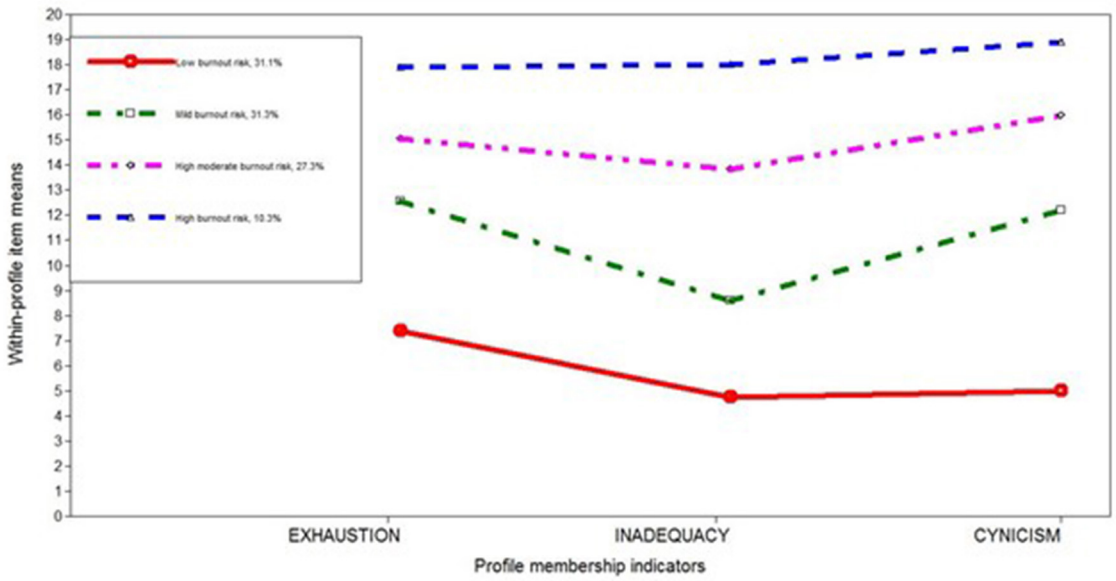

FIGURE 1 | Parameter estimates for the four-profile model of TB risk; within-profile item means.

TABLE 4 | Parameter estimates for the four-profile model.

		Low risk	Mild risk	High moderate risk	High risk
		1	2	3	4
Profile prevalence		***n* = 103**	***n* = 103**	***n* = 90**	***n* = 34**
Profile indicators	**Overall item means (*SD*)**	**Within-profile means Estimate (*SE*)**			
Exhaustion	12.18 (5.31)	7.39 (0.29)	12.56 (0.32)	15.04 (0.36)	17.90 (0.79)
Inadequacy	9.79 (4.88)	4.74 (0.18)	8.59 (0.22)	13.82 (0.46)	18.02 (0.59)
Cynicism	11.69 (4.51)	4.97 (0.17)	12.18 (0.33)	15.96 (0.23)	18.87 (0.54)

risk, included 31.2% of the teachers and was characterized by low levels of exhaustion and very low levels of inadequacy in the teacher–student relationship and cynicism toward the professional community. These results are significantly less than those obtained in all other profiles. The second profile, *Mild burnout risk*, included 31.2% of the teachers and was defined by moderate levels of exhaustion and cynicism on the one hand and low levels of inadequacy on the other. Therefore, the teachers with this profile have mild burnout risk, especially in terms of exhaustion and cynicism. The third profile, *High moderate burnout risk*, included 27.3% of the teachers and was characterized by high moderate exhaustion, inadequacy and cynicism. These results reveal a simultaneously increased pattern of all three symptoms of TB risk. The final profile, *High burnout risk*, included 10.3% of the teachers and was characterized by a similar pattern to the previous one but with higher levels of all three indicators.

TABLE 5 | Effects of predictors on membership in latent profiles of TB risk. Odds ratios (OR), 95% confidence interval for the effects of work-related stress on TB profile membership.

Burnout profile	Odds ratio (OR)	LL2.5%	UL2.5%
Reference profile: Low burnout risk			
"**Mild burnout risk**"			
Stress workload	2.190***	1.399	3.429
Stress student's misbehavior	1.410***	1.241	1.601
Stress professional recognition	1.180	0.911	1.528
Stress classroom resources	0.669	0.518	0.864
Stress poor relations	1.218	0.944	1.573
"**High moderate burnout risk**"			
Stress workload	3.139***	1.878	5.248
Stress student's misbehavior	2.146***	1.761	2.615
Stress professional recognition	0.971	0.677	1.392
Stress classroom resources	0.532	0.374	0.756
Stress poor relations	1.197	0.840	1.706
High burnout risk			
Stress workload	1.314	0.778	1.927
Stress student's misbehavior	0.865	0.387	1.937
Stress professional recognition	5.664**	3.124	8.178
Stress classroom resources	0.351	0.081	1.515
Stress poor relations	1.109	0.902	1.986

LL, lower limit of the confidence interval; UL, upper limit.
$^{**}p < 0.01$.
$^{***}p < 0.001$.

Antecedents of Latent Profiles

Having as reference the *Low burnout risk* profile, we noticed there was a significant tendency to increase the sources of stress generated by workload and students' behavior but only at the level of the *Mild burnout risk* and *High moderate burnout risk* profiles. In other words, these types of stress have a more pronounced impact on the high moderate than the mild burnout risk profile. Our findings revealed an interesting pattern. In the case of the *High burnout risk* profile, although the odds ratio (OR) for stress generated by workload was > 1, it did not reach the threshold of statistical significance and did not have a significantly higher contribution to this profile membership. The same pattern was obtained in the case of stress related to poor colleagues relations, that is OR > 1, $p = 0.64$. The stress generated by students' misbehavior did not have a significant impact either (OR < 1, $p > 0.05$). Furthermore, the results showed that the only significant contribution was the stress generated by low professional recognition, as set out in **Table 5**.

Socio-Demographic Variables as Covariates of TB Profile Membership

The results proved that gender did not have a significant impact on TB profiles. On the contrary, all the other socio-demographic variables were significant predictors of profile membership. In terms of teaching level, preschool teachers had higher odds ($OR = 1.42$, 95% CI [1.12, 1.81]) of belonging to the *Mild burnout risk* profile than to the *Low burnout risk* profile. Furthermore, our findings show that teachers with high professional experience had higher odds ($OR = 6.20$, 95% CI [2.79, 13.81]) of belonging to the *High burnout risk* profile than to the *Low burnout risk* profile. Comparing teachers according to urban/rural teaching environment, we found that those from rural schools had higher odds ($OR = 2.11$, 95% CI [1.77, 2.50]) of belonging to the *Higher moderate burnout risk* profile than to the *Low burnout risk* profile.

DISCUSSION

Our findings show that TB profiles were classified into four different categories: *Low burnout risk*, *Mild burnout risk*, *High moderate burnout risk* and *High burnout risk*. The profiles differed in all three symptoms of burnout—exhaustion, cynicism toward the teacher community and inadequacy in the pupil–teacher relationship. In addition, differences were found concerning teachers' stressors between profiles in terms of various types of stress, more precisely workload, students' misbehavior and professional recognition needs.

The first latent profile from our analysis was *Low burnout risk*. The teachers belonging to this profile displayed low levels of exhaustion, very low levels of inadequacy in the teacher–pupil relationship and cynicism toward the professional community. Additionally, the findings revealed that the levels of all three indicators of profile membership were statistically significantly lower than those in the other profiles. It is not surprising that teachers with the *Low risk burnout* profile do not experience symptoms of inadequacy in interaction with pupils and cynicism because previous studies have already highlighted that teachers who are less stressed are more efficacious (15, 21) and have better relationships with pupils (52, 53).

The second profile, *Mild burnout risk*, was characterized by moderate levels of exhaustion and cynicism toward the professional community on one side and low levels of inadequacy on the other side. Our findings proved that these mild burnout symptoms seem to be generated by the increase in stress generated by workload and students' misbehavior. Along the same lines, moderate exhaustion and cynicism was identified among Canadian teachers (32), where exhaustion was correlated with job demands.

The third profile, *High moderate burnout risk*, was characterized by teachers with high moderate symptoms of exhaustion, inadequacy in interactions with pupils and cynicism toward the professional community. In this case, the burnout symptoms are fueled by workload and students' misbehavior but with a stronger impact than in the case of teachers with the *Mild burnout risk* profile. In this regard, it seems that even during the pandemic period, workload and students' misbehavior remained the main stressors as before the pandemic (19, 24, 38).

The *High burnout risk* profile, the profile with the lowest prevalence ($n = 34$), represented the teachers who experienced higher levels of exhaustion, cynicism toward the teaching community and inadequacy in teacher–pupil interaction. In examining the *High risk burnout* profile, we noticed the teachers within it registered a high level of cynicism toward the professional community, unlike those in a study of Finnish

teachers (16). One explanation could be that in our sample the largest source of stress that had a statistically significant difference from other profiles was that generated by low professional recognition. If the feeling of inadequacy might be more closely related to intra-individual issues, such as self-esteem and general self-efficacy (41, 54), cynicism toward the professional community reflects dissatisfaction that has a rather external source than a dispositional trait (26, 55, 56) revealed correlates of cynicism such as social support, organizational commitment, and work–family or family–work conflict. It seems plausible that online teaching during the COVID-19 pandemic increased the level of stressors encountered by teachers, which in turn could affect organizational commitment and affective engagement and could accentuate possible previous family–work conflicts.

Another explanation could be related to the fact that professional recognition needs are translated into remuneration, career promotion prospects and social recognition (24, 40). As it is already recognized in JD-R model (29) that the lack of resources compared to demands would result in stress, which might eventually lead to TB and attrition (28) and that the perceived imbalance of effort and reward is associated with a high risk of developing burnout symptoms (57), it seems that for teachers with this profile the lack of gratification increased their burnout symptoms. This increase in the need for professional recognition could be due to the fact, as previous studies conducted during the pandemic have shown (10, 37, 58), that new teaching conditions produced new stressors for teachers and forced them to put extra effort into the teaching process (59), and thus the need for reward increased. Furthermore, despite that fact that stressors such as students' misbehavior and workload were present among teachers with the *High-risk burnout* profile, they did not make a significantly higher contribution for this profile membership compared to both previous ones.

Navigating through profiles from the high-risk level to the low risk level we gain valuable understanding of TB. In our case, the increased stress and frustration related to the lack of professional recognition in terms of remuneration, social recognition, and career opportunities together with the increased level of cynicism are what burdens teachers in this profile the most. Moreover, teachers' stress related to financial compensation was also identified among Bulgarian teachers (60), Slovak teachers (61), Greek teachers (62) and Turkish teachers (63) in the pandemic period. Thus, these challenging times seem to accentuate even more teachers' frustration related to professional recognition, especially in some European countries. Accordingly, further studies, particularly longitudinal person-oriented studies on professional recognition needs, are needed to test these assumptions.

As Huttell et al. (64) explained, burnout is not stable in nature and profile grouping is not a stable individual trait. The progression toward burnout and profile grouping can be reversed based on changes in the relationships between resources and demands. In this regard, burnout symptoms can appear anytime and have increased alarmingly during the COVID-19 pandemic, thus putting teachers' mental health at risk.

In the case of the average burnout risk profiles *Mild burnout risk* and *Moderate burnout risk*, differences from the reference profile, *Low burnout risk*, were found in terms of stress related to workload and students' misbehavior. Interestingly, the teachers belonging to this profile, even though they live under the same contextual settings, were not affected by the lack of social/professional recognition. Rather, they were stressed only by workload and students' misbehavior. One explanation for the fact that teachers belonging to these profiles were not affected by the lack of social/professional recognition could be that the frustrations related to lack of professional recognition were absorbed by their interest in the quality of their instructional process (7). Thus, according to the JD-R model (29), their passion and vocation were important internal resources that offset the new demands of the workplace, but they experienced limited resources in managing the increased workload generated by the new teaching conditions and a lack of resources in managing virtual relationships with students, being unprepared to find ways to maintain discipline in the online classroom (32).

The present study makes several contributions to the literature on TB (11, 16). First, it expands the body of research on TB in the challenging context of online teaching related to the COVID-19 pandemic. Second, it adds to the few studies that have been based on the mixture modeling approach, more specifically LPA, and has the advantage of having a person-centered approach rather than a variable-centered approach. Third, it is the first study to our knowledge that analyses the various types of work-related stress as antecedents of TB profiles. More precisely, the high levels of stress related to students' misbehavior and workload were related to a high probability of belonging to the *Mild burnout risk* and *High moderate burnout risk* profiles, while the high level of stress related to professional recognition needs generated a high probability of belonging to the *High burnout risk* profile. In this regard, it seems that the pandemic period accented stressors such as workload and students' misbehavior, which were reported even before the pandemic (24, 27, 38) as major inconveniences for teachers. To these was added a new stressor proximal to burnout, the lack of professional recognition.

In terms of socio-demographic variables, our findings revealed no association between gender and profile membership, which is in line with Pyhältö et al.'s (16) study. Preschool teachers had higher odds than primary school teachers of being included in the *Mild burnout risk* profile than in the *Low burnout risk* profile. One explanation for this finding could be the fact that the pandemic brought up new routines, such as extra handwashing, stricter sanitation requirements, different teacher–child ratios, prohibiting parents from entering preschools and social distancing (65, 66), all of which increased kindergarten teachers' physical and mental stress. As mentioned, an interesting pattern emerged; in our research, teachers with higher professional experience had a higher burnout risk in the context of remote learning related to the COVID-19 pandemic than less experienced teachers. However, it seems plausible if we take into account that in online teaching younger teachers have been more advantaged due to stronger digital skills compared to older teachers who have encountered greater difficulties in adapting to e-learning systems (67, 68). Additionally, teachers in rural educational environments were at high moderate risk of burnout compared to those teaching in urban environments.

This finding seems to be very relevant, first because the lack of infrastructure for broadband access in some rural areas often constrained rural teachers in terms of having to operate with fewer resources than their urban counterparts (69).

The current study has some limitations that should be noted. First, the study used a convenience sampling technique; therefore, the findings cannot be generalized. Second, the use of cross-sectional data in this study necessitates further longitudinal and experimental design studies. More specifically, the cross-sectional design and R3STEP approach used in the specified mixture model reveal various exogenous covariates of burnout profiles, that is, work-related stressors but no causal links with TB. Therefore, future longitudinal studies are needed to capture how to evolve the relationship between various types of work-related stress and socio-contextual burnout after the remote learning period and after the COVID-19 pandemic. In addition, in terms of future research directions, more studies are needed to find the factors that lead to increased levels of cynicism toward professional community and explore if they are either intra-individual or socio-contextual in nature. Additionally, because a broader cul-tural context is very complex but was not the focus of the present article, further cross-cultural comparative studies on burnout should be conducted.

Practical Implications

Considering the prevalence of teachers in two of four profiles determined in the present study, namely *High moderate risk* and *High burnout risk*, it should be considered a priority to identify as early as possible the teachers at risk for the onset of burnout symptoms and those who have difficulty managing work-related stress. Taking into account that the most common antecedents or risk factors for TB proved to be workload and students' misbehavior, it is tremendously important that teachers at risk ask for and receive help so that the burnout symptoms do not affect their health, their relationships with pupils and their personal lives. In this regard, the closest resource is social support (53). For example, collaborative teaching could help in buffering burnout symptoms by sharing work, asking for advice, bringing out concerns and receiving help from co-workers (70). In addition, an intervention program based on cognitive behavioral therapy and mindfulness-based stress reduction has proven effective in reducing TB (71) and should be considered for implementation in order to support teachers' mental health during the pandemic and beyond.

Concerning professional recognition needs that proved to be a major stressor, we highlight that teachers may be able to tolerate a greater workload if they feel they are well-rewarded for their efforts and if they value their work with children (72). Therefore, our study encourages cross-cultural learning and sharing among preschool and primary school teachers through teacher exchanges and collaborations that can generate a unique understanding of the best ways to fight TB.

CONCLUSIONS

In summary, our study expands the empirical body of research on TB risk (16, 20, 32, 53) by being the first study to explore TB symptoms and work-related stressors during the COVID-19 pandemic using a person-centered approach. The results showed that over half of the teachers in our sample were affected to varying degrees by low to high burnout symptoms. Four TB profiles were identified. Workload, students' misbehavior and the lack of professional recognition were the major stressors that contribute the most to TB profile membership. The pandemic context brought to light a new stressor proximal to TB—professional recognition needs. In this regard, the present study highlights that educational managers could support teachers' health and well-being by: (1) knowing teachers' needs, worries and stressors in order to prevent the appearance of symptoms of exhaustion, inadequacy in the teacher–pupil relationship and cynicism toward the professional community; (2) decreasing burnout through supportive programs based on developing skills for classroom management in various learning environments, time management and work–life balance; and (3) professional development programs that promote career opportunities such as self-actualization, visibility and social recognition.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Bucharest Ethics Committee (no 11/26.04.2021). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

C-MR contributed in conceptualization, developed the questionnaires, and collected the data. ES and C-MR developed the analytical plan, undertook the statistical analyses, interpreted the results of the statistical analyses, and wrote the paper. Both authors have read and agreed to the published version of the manuscript.

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Semantics–Prosody Stroop Effect on English Emotion Word Processing in Chinese College Students With Trait Depression

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This study explored the performance of Chinese college students with different severity of trait depression to process English emotional speech under a complete semantics–prosody Stroop effect paradigm in quiet and noisy conditions. A total of 24 college students with high-trait depression and 24 students with low-trait depression participated in this study. They were required to selectively attend to either the prosodic emotion (happy, sad) or semantic valence (positive and negative) of the English words they heard and then respond quickly. Both prosody task and semantic task were performed in quiet and noisy listening conditions. Results showed that the high-trait group reacted slower than the low-trait group in the prosody task due to their bluntness and insensitivity toward emotional processing. Besides, both groups reacted faster under the consistent situation, showing a clear congruency-induced facilitation effect and the wide existence of the Stroop effect in both tasks. Only the Stroop effect played a bigger role during emotional prosody identification in quiet condition, and the noise eliminated such an effect. For the sake of experimental design, both groups spent less time on the prosody task than the semantic task regardless of consistency in all listening conditions, indicating the friendliness of basic emotion identification and the difficulty for second language learners in face of semantic judgment. These findings suggest the unneglectable effects of college students' mood conditions and noise outside on emotion word processing.

Keywords: semantics–prosody Stroop, English, emotion word processing, trait depression, college students

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INTRODUCTION

Among all sources and respects of emotional communication cues, the comprehensive process of multisensory integration is typically employed to reach a locutionary conveyance. This ability to perceive and combine both linguistic messages (i.e., verbal content meaning) and paralinguistic messages (i.e., non-verbal cues by pragmatic context, body language, and tone of voice) facilitates sophisticated social interaction (1, 2). Yet, the co-occurring semantic meaning and emotional cues in utterances simultaneously are not always presented in a consistent state, and the very discrepant messages combined may lead to delays or even challenges to a correct interpretation of true emotional expression (3–6).

As two prime channels for emotional speech interaction, verbal content and prosodic information mainly bridge the daily communication linguistically and emotionally. The general semantic meaning of speech enjoys the main content of emotional expression, but often the

paralinguistic messages serve as completion and exterior presentation in physical forms (7). Therefore, verbal content acts as the most common means, and prosodic information is one of the most fundamental aspects of social interaction (8). Prosodic cues even present a clearer emotional tendency, particularly when verbal form representation is obstructed due to implicitness or other language barriers (9). By means of changes in pitch, loudness, speech rate, and pauses (10), emotional prosody reveals various non-verbal respects of language that make speakers convey emotional cues in conversation (11). But in real communication practice, emotional prosody can be isolated from semantic information, and in return interacts with verbal content, as a consequence of irregular verbal expression [e.g., sarcasm; (12, 13)].

Empirical research under the Stroop effect paradigm (14) examined the emotional interactions with these informative dimensions through cross-channel and cross-modal experiments (9, 15). With participants facing congruent and incongruent stimuli under different modalities, the inter-competence between linguistic information and paralinguistic information in emotional speech processing would be presented, suggesting relative dominance of either of them (16, 17). Participants performed better with congruent stimuli, while the prolonged reaction time and poorer accuracy rate were caused by specific but conflicting stimuli, which was in line with the congruence-induced facilitation effect and on the other hand, the incongruence-induced interference effect (18–20).

However, interpersonal and social interactions pose challenges for major depressive people, since major depression is closely connected with cognitive impairments in memory and executive functions (21, 22). Depression, a mood disorder marked especially by sadness, inactivity, difficulty in thinking and concentration, has increasingly become a major threat to human life and has arisen significant interest both in the pathological characteristics and the social performance of the patients (23–25). And people with the depression-related illness often display a quite fixed pattern of negative thinking about experience, values, and the whole world generally, and the correct social interaction and interpretation can be compromised (26).

As a subclinical state of depression, trait depression is the exact and frequently occurred tendency of an individual to experience depressive emotions (27). Being regarded as being below the diagnostic criteria for depression clinically, trait depression shares some similarities with depression on cognitive and physiological deficits (28), including pessimism, inferiority, loneliness, and unworthiness (27). As mentioned above, people with major depressive disorder (MDD) presented no self-positivity bias, and they even presented self-negativity bias, which connected more closely with negative information, leading to more automated processing of negative information in the environment (29–31). The lack of self-positive bias makes trait-depressive individuals make people succumb to depression disorders more easily, meaning the group of people who have not yet developed depression disorder but mostly are susceptible. The trait mirrors the long-term emotional stability of their state of mind (32). Although the introduction of various experimental designs and assessment scales availed research for MDD patients, the emotional speech processing for people with trait depression lacks solid evidence. Studies on emotional speech processing in trait-depressive people are quite scarce (33), partly due to the lack of attention on this specific group of people with mood disorders tendency, and partly due to the lack of a scales for the professional assessment of depressive state and trait (26, 34).

In view of previous studies employing the Stroop-like paradigm to investigate emotional processing, only a few of them focused on college students with trait depression. What is still worth mentioning is mainly the variants of the experimental design. First, studies on emotional speech processing exploring the interaction between word information and emotional prosody are rich. The congruency of affective prosody and word valence facilitated the emotional processing, which was corroborated by later studies (35, 36). The relatively salient role of paralinguistic prosodic information over semantics in emotion word processing was presented with both cross-channel and cross-modal behavioral evidence (9). Second, many previous studies on emotional processing performed on participants with MDD showed quite consistent results. The key role of correct interpretation of emotional signals across verbal and non-verbal channels can be worse (37, 38). The cognitive patterns displayed by MDD patients presented the impaired perception of positive cues and the enhanced attention to negative cues as well in emotional communication (39, 40). Such biased emotional perception has been attested by plenty of studies *via* face recognition (41–43) and a few studies *via* voice recognition (44). These are in accordance with findings at the neurophysiologic level presenting a reduction of activation in frontal and limbic areas in MDD patients (45, 46). Third, Gao et al. (47) presented the mechanisms of the "bilingual advantage effect" under the condition of different languages in the Stroop task. It turned out that skilled bilinguals performed better and presented stronger inhibitory control ability under the condition of the first language than monolinguals. And these bilinguals possessed better information monitoring ability and conflict resolution, which shed some light on the variants of the Stroop paradigm in terms of language capability (48).

To date, very few studies on emotional processing employed vocal speech as auditory materials to explore the performance of college students with trait depression. In the research field of psychology and sociology, the study concerning emotional conflict of college students with trait depression under the Stroop paradigm variants in the visual modality merely examined the different responses of participants under emotionally consistent and inconsistent conditions between words and facial expressions (33), showing emotional consistency effects (i.e., the fact that participants had higher accuracy and shorter response time under the word–face consistent condition). Gao et al. (33) found that the accuracy of the high trait depression group was significantly higher than that of the low trait depression group in all conditions. But the response time of the high trait depression group was significantly lower under the condition of emotional inconsistency, partly because participants tended to use a kind of processing strategy to complete the cognitive task more conveniently, according to the Emotion Infusion Theory proposed by Bower (49). Therefore, high trait-depressive

participants may have a state of readiness and be able to judge the valence of emotion and face more quickly.

Within the existing literature, the studies concerning emotional prosody were examined either in MDD patients or under the simplified semantics–prosody paradigm (in lack of word valence in some experiments). Of all, the marked inclination of emotional conflicts and emotional prosody in participants with MDD seems quite certain and a truism in a general way. And studies ranging from facial signals to human voice and even cross-modal are increasingly mature and complete. Yet, research on emotional prosody in trait-depressive college students under a complete semantics–prosody Stroop effect paradigm is still quite poor. Furthermore, relevant studies were all conducted under the ideal experimental condition, rather than under background noise with ecological value. Moreover, individual differences were rarely considered as a significant factor affecting participants' performance in certain experimental circumstances. Different levels of second language proficiency and personal state of mind are not negligible. So, this study will discuss the interaction of semantic content and emotional prosody during emotion word processing by human voice under a complete Stroop effect paradigm, with different severity of Chinese trait-depressive college students as participants, trying to explore the differences between and within groups, and then to shed light on the undiscovered land.

The current study applied the experimental protocols of Schirmer and Kotz (36) and investigated the English emotion word processing in Chinese college students with trait depression through cross-channel experiments. In terms of participants, the second language proficiency and their severity of trait depression varied more or less because of the well-known individual differences, embodying some of the individuals' proficiency in speech perception (50). For these second language learners of English, the aural English words, to some extent, turn into a language barrier as the second language proficiency, but it is less likely to appear the ceiling effect since all English words we selected in this experiment as language materials are "everyday words" with fair verbal valence. These words were produced with happy and sad emotions, which were the two most distinguished and uncontroversial emotions shared across cultures (51, 52). Besides, participants' long-term state of mind with depressive emotions exerts influence on the perception of emotional prosody (53). Experiment 1 employed both semantic valence judgment with and without prosody–congruency stimuli (i.e., the semantic task), and emotional prosody judgment with and without semantic–congruency stimuli (i.e., the prosody task) to explore the altered perception of speech emotions. Based on the poor performance of MDD on semantic and emotional prosody work, people with trait depression might also present prolonged response time and insensitive emotion recognition on the emotion word processing through verbal and non-verbal channels, thus less Stroop effect in semantic valence judgment. Following the same protocols, Experiment 2 stimulated a more authentic locutionary situation by means of the speech-shaped noise (i.e., an energetic environmental degradation), which added difficulties and interference in emotion word perception both linguistically and prosodically, to break the limit of the singular laboratory environment and reach conclusions with broader sense (54, 55). In this case, we hypothesized that the noisy condition might aggravate the emotional perception difficulty for the high trait-depressive group.

In a nutshell, with the second language–based and psychology-related behavioral study, we aimed to explore further the mechanisms of emotional perception in college students with trait depression specifically. By contrasts between different severity of trait depression and different levels of listening conditions, practical patterns of the Stroop-like paradigm and theoretical frameworks of emotional processing would be enriched in greater detail, which could facilitate the effective probe of nature about multiple channels of the cognitive process for clinical populations.

MATERIALS AND METHODS

Participants

In total, 48 Chinese college student volunteers (24 men and 24 women) were recruited for this experiment, all born in China and native Mandarin speakers. Age varied from 18 to 26 years. They were graduate or undergraduate students who had English as their second language, and they have passed CET-4 (College English Test Band 4). All participants' trait depression scores were evaluated based on the Chinese version of the State-Trait Depression Scale (ST-DEP), which was proposed by Spielberger (56) and then translated into Chinese by Lei et al. (26). With evidence of being highly valid and more focused on the assessment of cognitive and affective factors, it serves as an effective measure to distinguish between depressive state and trait (57). With a full score of 16–64, students with higher scores would be regarded as participants with high-severity trait depression and likewise, college students with lower scores would be regarded as participants with low-severity trait depression in the current study (26). Specifically, the high-trait group (n = 24) comprised 11 men and 13 women who scored above 40 but no more than 64 in the T-DEP, while the low-trait group (n = 24) contained 13 men and 11 women who scored above 16 but no more than 30.

Furthermore, all participants were tested for their English skills with the LexTALE test, an efficient vocabulary test to measure L2 language proficiency (58), and phonological short-term working memory (WM) with a digit-span test, the information held temporarily for use in immediate activities such as reasoning and decision making, which serves as a significant indicator of language learning ability (59). In addition, they fulfilled the self-rating of Emotional Intelligence Test [SREIT; (60)], a 33-item scale concerning mental representation and utilization of emotions. The demographic characteristics of participants are presented in **Table 1**. As displayed, there did exist significant group differences between the high trait depression group and low trait depression group in terms of T-DEP and SREIT, but not in the age, LexTALE, and WM.

All participants were right-handed with normal or corrected vision, and only those who reported no history of speech, hearing impairment, no musical training, or had no experience of major

TABLE 1 | Basic information of participants.

	High-trait group (n = 24)		Low-trait group (n = 24)		
	M	**SD**	***M***	**SD**	***p***
Chronological age	21.96	2.07	22.25	1.87	0.611
T-DEP	44.92	4.98	25.54	4.01	**<0.001*** **
SREIT	113.26	12.37	129.63	13.76	**<0.001*** **
LexTALE	54.74	5.82	55.48	7.46	0.703
WM	27.42	1.72	27.01	3.39	0.595

*Means (and standard deviations) of chronological age, T-DEP, SREIT, LexTALE (L2 vocabulary size), and WM for the high-trait group and low-trait group. T-DEP, Trait Depression Scale; SREIT, Self-Rating of Emotional Intelligence Test; WM, working memory. ***p < 0.001.*

depressive therapy were recruited in the current study (61). This study was approved by the (institution redacted for peer review) to ensure proper compliance with the informed consent procedure. Participants completed the informed consent at the study and got reimbursed for their participation.

Stimuli

The stimuli we employed in the study contained 120 English words (60 verbs and 60 adjectives) carefully selected from "The Oxford 3000," a list of the 3,000 most important words to learn in English from the Oxford English Corpus, and "The Longman Communication 3000," a list of the 3,000 most frequent words in spoken and written English that account for 86% of the language, to avoid rare words and therefore guarantee the understandability for these second language learners of English. The whole stimulus set (American spelling) included 60 positive words and 60 negative words based on a pilot study of valence ratings obtained from four advanced English speakers and one native speaker who did not participate in either of the experiments. They were instructed to judge the semantic valence of the words in a randomized order on a 5-point scale from −2 (highly negative) to 2 (highly positive). Negative words had a mean valence of −1.43 (SD = 0.24), and positive words of 1.44 (SD = 0.35), showing no significant difference in valence strength (positive words were rated just as strong as negative words). Additionally, word frequency was counted by means of the Corpus of Contemporary American English [COCA; (62)]. As shown in **Table 2**, the positive words presented a similar word frequency as the negative words; positive and negative words showed comparable syllable numbers.

A Canadian male speaker (35 years old) produced all English words clearly in a quiet setting with happy and sad prosody (240 stimuli = 120 words × 2 prosodic categories), which were subsequently normalized to the same duration (1,000 ms). The pitch, however, was different between happy and sad prosodies ($p < 0.001$). Specifically, words read in happy prosody had an average pitch of 154.07 Hz (SD = 43.04) and words read in sad prosody of only 98.72 Hz (SD = 6.67), which is in line with the acoustic attributes of happy and sad utterances (63). Thus, pitch variations in accordance with the speaker's emotion serve as assistant effects for listeners to complete the prosody-identification task (64).

TABLE 2 | Word frequency and syllable numbers of selected English words.

	Type	***M*** **(SD)**		***M*** **(SD)**	***p***
Word frequency	Positive	44813.18 (21884.29)	Negative	39013.72 (20774.27)	0.14
	List 1	41913.77 (21433.09)	List 2	41913.13 (21638.33)	0.99
	Adjectives	40596.93 (21929.90)	Verbs	43229.97 (21051.11)	0.50
Syllable numbers	Positive	2.03 (0.78)	Negative	1.97 (0.74)	0.63
	List 1	1.98 (0.77)	List 2	2.02 (0.75)	0.81
	Adjectives	2.07 (0.84)	Verbs	1.94 (0.66)	0.34

Moreover, though the same words were employed as stimuli in two experiments, we added noise (SNR = 10 dB) to the audio files for Experiment 2 to create a noisy condition. The whole stimuli were divided into two lists (List 1 and List 2), with each list containing 30 positive and 30 negative words spoken by happiness and sadness prosody, conveying both semantic meaning and prosodic emotion to participants simultaneously. Thus, under different instructions of tasks, participants accordingly pay selective attention to either semantic valence information or emotional prosody information of the auditory stimuli. Notably, each list was presented under arrangement on different tasks. Therefore, half of the participants already having heard one list of words under semantic instruction would hear the other list of words under prosodic instruction and *vice versa*.

Task and Procedures

The whole experiment was conducted in a quiet room and each participant was seated in a comfortable chair facing a computer monitor, a noise-canceling headphone, and a Chronos box [an E-Prime-based device with high accuracy of response time; (65)]. Two tasks were performed for participants to selectively attend to word valence information (semantic task: positive or negative) or emotional prosody information (prosody task: happy or sad) of auditory stimuli under corresponding instructions in quiet (Experiment 1) or noisy (Experiment 2) environment. In both experiments, instructions and auditory stimuli were presented by E-Prime [Version 3.0; (66)] on the computer, with the stimulus presentation program customized in advance. Having received the standard auditory information of English words through the noise-canceling headphone (Sennheiser HD280 Pro) binaurally at a comfortable sound intensity level (65 dB SPL), participants offered their responses by pressing the corresponding button of Chronos as quickly and as accurately as possible to indicate their judgments. The accuracy and response time recorded by Chronos would then serve as the measurement.

Participants were told to complete the practice session first as a familiarization process with four spoken words in the semantic task and prosody task, respectively, and these eight words were not used in the real experiment. After participants responded, the instant accuracy would be presented on the screen. Those who reached at least 80% accuracy would enter the formal task phase.

TABLE 3 | Results of linear mixed effects model on reaction time (full presentation with results of both Experiment 1 and Experiment 2).

Effect	Chi-square	*p*
Severity	4.26	0.039*
Congruency	123.90	<0.001***
Task	69.93	<0.001***
Condition	7.96	0.005**
scale_Trial	28.57	<0.001***
scale_Digit span	0.14	0.706
LexTALE	5.21	0.022*
Severity:Congruency	0.01	0.910
Severity:Task	6.45	0.011*
Congruency:Task	9.38	0.002**
Severity:Condition	17.01	<0.001***
Congruency:Condition	0.06	0.801
Task:Condition	13.56	<0.001***
Severity:Congruency:Task	0.06	0.808
Severity:Congruency:Condition	1.14	0.285
Severity:Task:Condition	0.07	0.785
Congruency:Task:Condition	2.26	0.133
Severity:Congruency:Task:Condition	4.45	0.035*

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

In formal experiments, for word valence and emotional prosody in each experimental stimulus, participants were instructed to pay main attention to only one respect, though the twofold pairings with two different channels presented either congruency (positive-happy, negative-sad) or incongruency (positive-sad, negative-happy). Specifically, under the instruction of semantic information, participants would identify word valence as positive or negative while ignoring the prosody in this "semantic task." On the other way around, in the "prosody task," participants would judge emotional prosody as happy or sad under the instruction of prosody information while ignoring word valence. Instructions were visually presented on the computer screen to make sure participants' full understanding of each task. Stimuli were presented in a randomized fashion within different tasks to each participant. Unlike the familiarization session, no instant feedback of accuracy would be presented on the screen to avoid the unnecessary distraction of participants, and the session would proceed to the next trial if no response was recorded within 5,000 ms.

Experiment 2 followed the same procedure of the protocols and employed the same word in the quiet environment of Experiment 1, only the speech-shaped noise at a fixed signal-to-noise ratio (SNR = 10 dB) was affiliated to create a noisy environment in Experiment 2, with the effect of energetic masking (67, 68). The SNR of 10 dB was determined based on a pilot study, which reached the lowest SNR level with a minimum accuracy of 80% in both tasks. To avoid the fatigue effect, there was a short break between two experiments, which were presented to participants in random order. The whole experiment took approximately 1 h.

Data Analyses

For statistical analyses, a range of calculations were performed in R [Version 4.1.2; (69)]. For the collected data, 48 subjects participated in two experiments, with each experiment containing 2 tasks and each task containing 120 items, 23,040 data were obtained in total ($48 \times 2 \times 2 \times 120 = 23{,}040$ observations). As for the preliminary data filtering process, only data with reaction time between 100 ms to 2,500 ms were counted as acceptable in the experiment to enhance data validity, since neither the excessive speed nor the noticeable delay in response time was admitted in the study. Then, we eliminated incorrect responses, and 18,809 observations were kept eventually. Besides, we also performed a log transformation to reaction time data since in many perceptual experiments response time exhibits positive skewness (70). Furthermore, to compare the inter-group difference of T-DEP scores, SREIT scores, and WM between high-trait group and low-trait group, we employed two-sample *t*-tests with the R package of ez (71).

In general, a linear mixed-effect model (LMM) was constructed using the R package of lme4 (72). Considering the huge difference between types of data, the trial number of words and digit-span scores of participants were centered and therefore reached normalization. When fitting all the LMMs in the analyses of the two identification data, "Reaction time" was counted as the dependent variable. Fixed factors: "Severity (high vs. low)," "Congruency (congruent vs. incongruent)," "Task (semantic vs. prosodic)," "Condition (quiet vs. noisy)," and all their interactions; two random factors: "Participant" and "Item," were included in the model. And controlled co-variants were LexTALE scores, working memory, and normalized trial number. By-participant random intercepts and slopes for all possible fixed factors were included in the initial model (73), which was compared with a simplified model that excluded a specific fixed factor using the analysis of variance (ANOVA) function in lmerTest package (74). The model was fitted to optimize it. Besides, Tukey's *post hoc* tests were employed using lsmeans packages (75) to elaborate the significant interaction effects when necessary.

RESULTS

Statistics suggested that the mean age of participants is 22.10 (SD = 1.96, range = 18–26) years, and they have received an average of 15.83 (SD = 1.84) years of formal education. **Table 3** presents the fullest results of the LMM on these participants' reaction time across two experiments, showing a significant four-way interaction of "Severity" × "Congruency" × "Task" × "Condition" [χ^2 (1) = 4.45, $p < 0.05$], which was further separately analyzed under two different conditions (quiet and noisy conditions), namely, Experiment 1 and Experiment 2.

Experiment 1 (Quiet Condition)

Figure 1A shows high-severity and low-severity trait-depressive participants' reaction time in semantic-emotion interference tasks in quiet condition. As displayed in **Table 4**, in the quiet condition, a significant two-way interaction of "Severity" × "Task" was found [χ^2 (1) = 4.14, $p < 0.05$]. The following *post hoc* tests showed that when participants conducted

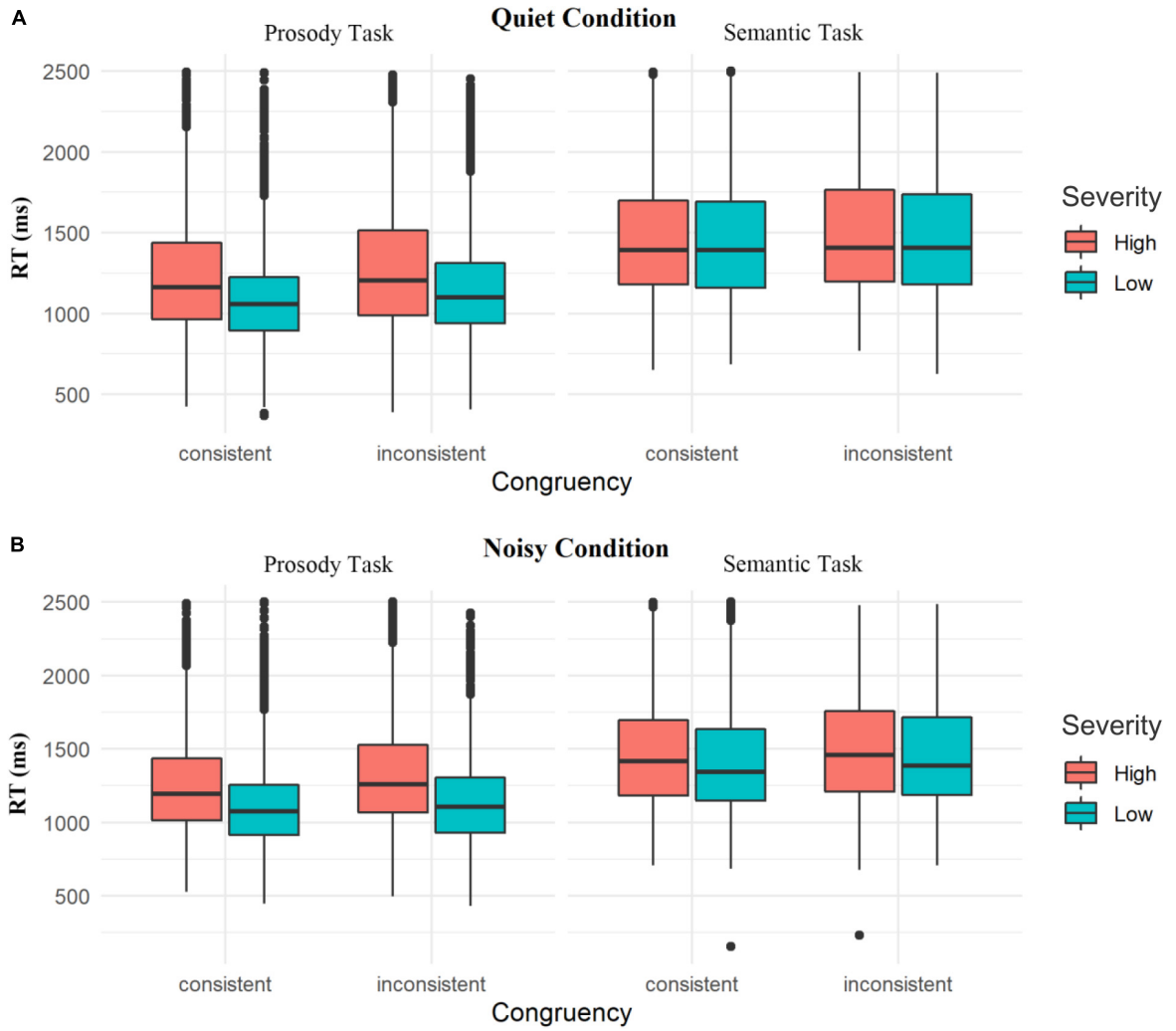

FIGURE 1 | Box plots of reaction time in participants with low and high trait depression across consistency (consistent vs. inconsistent) in prosody and semantic tasks in the quiet condition **(A)** and noisy condition **(B)**.

the prosody task, high-trait group reacted slower than low-trait group ($\beta = 0.094$, $SE = 0.047$, $z = 1.978$, $p < 0.05$), but there exists no such significant difference when they conducted semantic task ($\beta = 0.008$, $SE = 0.027$, $z = 0.278$, $p = 0.781$); in general, participants reacted faster in the prosody task regardless of their trait depression scores ($ps < 0.001$).

As **Table 4** displays, a significant two-way interaction of "Congruency" × "Task" was found as well in the quiet condition [χ^2 (1) = 9.82, $p < 0.01$]. More specifically, when performing both prosody ($\beta = -0.054$, $SE = 0.007$, $z = -7.700$, $p < 0.001$) and semantic ($\beta = -0.022$, $SE = 0.007$, $z = -3.035$, $p < 0.01$) tasks, both high-trait group and low-trait group spent less time under consistent situation compared with inconsistent situation. The results displayed that participants tended to be more affected by semantic congruency (or not) in the prosody task than be affected by prosody congruency (or not) in the semantic task.

There was also a clear fact that regardless of consistency or not (the Stroop effect set on the experiment), they spent less time when they conducted prosody task rather than semantic task ($ps < 0.001$).

Experiment 2 (Noisy Condition)

Figure 1B displays high-trait and low-trait groups' reaction time in semantic and prosody tasks under a noisy condition. As displayed in **Table 5**, in the noisy condition, LMM revealed a clear main effect of "Congruency" [χ^2 (1) = 34.61, $p < 0.001$] in the noisy condition, while the two-way and three-way interactions between "Congruency" and any other factors failed to reach significance (all $ps > 0.05$). Notably, while "Congruency" and "Task" produced a two-way interaction and the Stroop effect therein made differences in the two tasks in a quiet condition, no such interaction was found in the noisy condition.

Besides, a significant two-way interaction of "Severity" × "Task" was detected in the noisy condition [χ^2 (1) = 83.11, $p < 0.001$]. When participants conducted the prosody task ($\beta = 0.126$, $SE = 0.035$, $z = 3.611$, $p < 0.001$), the

TABLE 4 | Linear mixed-effects model with severity, congruency, task as the fixed effects and the logarithm of reaction time as dependent variables in Experiment 1.

Effect	Chi-square	*p*
Severity	2.34	0.126
Congruency	56.36	<0.001***
Task	60.25	<0.001***
scale_Digit span	0.35	0.553
scale_Trial	14.06	<0.001***
LexTALE	5.88	0.015*
Severity:Congruency	0.63	0.427
Severity:Task	4.14	0.042*
Congruency:Task	9.82	0.002**
Severity:Congruency:Task	2.43	0.119

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

TABLE 5 | Linear mixed-effects model with severity, congruency, task as the fixed effects and the logarithm of reaction time as dependent variables in Experiment 2.

Effect	Chi-square	*p*
Severity	4.65	0.031*
Congruency	34.61	<0.001***
Task	1539.82	<0.001***
scale_Digit span	0.00	>0.999
scale_Trial	19.97	<0.001***
LexTALE	2.07	0.150
Severity:Congruency	0.00	>0.999
Severity:Task	83.11	<0.001***
Congruency:Task	0.72	0.395
Severity:Congruency:Task	1.50	0.220

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

group difference was quite clear: high-trait group took a longer time to identify emotions expressed by noisy-interferential spoken English words than low-trait group, which closely resembled the results in the quiet condition. However, there was no such significant difference between two groups when they conducted the semantic task ($\beta = 0.036$, $SE = 0.035$, $z = 1.035$, $p = 0.301$).

Besides, in the noisy condition, both high-trait and low-trait groups took a shorter time to complete the prosody task than the semantic task ($ps < 0.001$). Primarily, these data presented that Chinese college students tended to identify emotions faster than L2 verbal content under all listening conditions.

DISCUSSION

So far, the question remains unresolved as to how people with a propensity to depression process emotional cues of the second language during daily communication. To fill the research gap of emotion word processing for second language learners with different severity of trait depression, the current study investigated the interaction of semantic content and emotional prosody under a complete Stroop effect paradigm by Chinese college students with trait depression in quiet and noisy environments. It was designed to address the following three research questions. First, we tried to investigate the differences between high trait-depressive group and low trait-depressive group in emotion word processing. Second, we were interested in the general mechanisms of the Stroop effect on emotion word processing in two severity of trait-depressive groups. And finally, we aimed to figure out whether any change in English emotion word processing would be posed by the influence of noise. The following discussions tried to answer these research questions based on relevant findings.

Specific for High Trait-Depressive Group: Bluntness Toward Emotions

For the issue of Chinese college students in terms of the emotional prosody identification, results of the current study showed that in two experiments, the response time of the high-trait depression group was significantly longer than that of the low-trait depression group regardless of the congruency condition. This finding of the semantics–prosody Stroop experiment, however, is not congruent with previous findings of the word–face Stroop experiment with trait-depressive college students (33). They found that the response time of the high-trait depression group was significantly shorter than that of the low-trait depression group under the condition of emotional inconsistency. In order to explain this, the authors adopted the Affect Infusion Model (49), meaning participants took strategies in advance and processed information more conveniently, potentially accounting for this phenomenon. So, it is the earlier readiness for cognitive processing more conveniently that assisted the high-trait depression group to react faster.

The poorer performance of emotional processing in high-trait depression people is generally in line with previous studies of emotion-related judgment in patients with MDD. Previous studies presented their impaired recognition of emotions in the visual modality (i.e., facial expressions) or auditory modality (i.e., emotions are expressed vocally). They seemed to show deficits in the correct perception of affective prosody (76). And in most rating experiments, MDD tended to skew the recognition of emotional stimuli into two directions: the tendency toward negative emotional stimuli, and the bluntness of positive stimuli (38). Since trait-depressive undergraduates are associated with low heart rate variability and more specifically its parasympathetic component, which is considered a physiological index of emotion regulation capacity (77), they are less competent to regulate their emotions and reach controlled sensory processing. Participants got poor concentration toward outside information with increasing severity of depression.

Both in quiet and noisy conditions, the results of the current study showed clear contrasts of reaction time between different trait-depression groups in the prosody task, while no such significant contrast was found in the semantic task. This is plausible due to the closer connection between the prosody task and the effect on the long-term psychology of participants.

General for Participants: Extensive Existence of Stroop Effect

Variants of Stroop effect protocols, as behavioral experiments, were considered as an exploration of the primitive operations of cognition, offering clues to the fundamental process of attention

and an ideal tool for the research of automatic processing (78). Results of the current study showed the consistency facilitation effect, meaning that participants took a shorter response time under emotional consistency conditions, which is congruent with previous findings (9, 18, 19). Interestingly, the high-trait depression group lacked activated sensitivity toward emotion perception, then they might have been less affected by the change of emotional prosody when they conducted semantic tasks. However, the lack of two-way interaction of "Congruency" and "Severity" in Experiment 1, indicated that the effect of congruency of stimuli from two channels did not vary between the high-trait group and the low-trait group. Besides, the main effect of "Congruency" in Experiment 2 symbolized the "independence" of the Stroop effect from the mental state of individuals inside (i.e., participants' trait depression severity) and environmental influences outside (i.e., quiet and noisy listening conditions). The results were roughly analogous, jointly indicating an extensive existence of the Stroop effect.

Notably, the anterior cingulate cortex and dorsolateral prefrontal cortex were reported to remain active when resolving conflict (79), indicating the brain activity in Stroop interference. And the widespread view about the Stroop effect in cognition told that mental skills (e.g., reading) are automatic once they were acquired through repetitive and extensive practice (80). Cattell (81) suggested an automatic process in the cognitive science of the Stroop effect. The automatic process was regarded as unintentional, uncontrolled, unconscious, and fast (82). Just as in the word–color experiment initially, participants in the current study could not "resist" processing word meaning in the prosodic task or pay attention to emotional prosody in the semantic task, and the interference made the difference.

Noise in Emotion Word Processing: Masking Effect

While the Stroop effect presented high automation, it did make a varying difference between semantic task and prosody task in the quiet condition. More specifically, in Experiment 1, under the interaction of "Congruency" and "Task," "Congruency" exerted a higher influence in the prosody task ($^{***}p < 0.001$) than in the semantic task ($^{**}p < 0.01$). In other words, all participants were more affected by the Stroop effect in emotion identification with the interference of English word content, which might relate to experimental design. One potential factor to account for this could be that, compared with the word valence judgment in the semantic task, identifying emotions as happy or sad in the prosody task was easier for participants, which could be proved by the reduced response time. First, we selected the two most uncontroversial emotions that share across multi-cultures as the basic emotions. Unlike other finer emotions (e.g., suspicious, surprising, sarcasm, regret), familiarity and understandability increased the response efficiency. Therefore, it is very much unlikely for participants to misinterpret them. Second, given the significant pitch difference of audio stimuli between happy tone and sad tone, there existed an obvious contrast, with happy tone much higher than sad tone ($p < 0.001$), while no such significant pitch contrasts between positive and negative words were observed ($p = 0.808$). This was not surprising since the happiness expression was always presented with explicit and unneglectable acoustic cues, such as higher pitch and quicker speed (64). Thus, participants reached faster responses within a short time. Third, although college students in this experiment have received an average of 15.83 years of education and learned English from a young age, they did not achieve perfect scores in LexTALE ($M = 55.11$). In semantic task, listening to English audio files only once and reacting within 5 s for second language learners could be a demanding task of pretty pressure, accompanied by a significant decrease of attention toward the emotional prosody of English words and a less Stroop effect. On the other hand, in the prosody task, going much easy on the emotion identification could always leave much other room for attention to verbal content, and the semantics–prosody channel congruency (positive-happy, negative-sad) or incongruency (positive-sad, negative-happy) mattered more. This aligned with the perceptual load theory: to what extent the task-irrelevant stimuli are processed is determined by whether there are spare attentional resources left when they are used to process the task-relevant stimuli (83).

However, this varying degree of Stroop effect between two tasks was not consistently observed in Experiment 2, where the listening background changed from quiet to speech-shaped noise. The interaction of "Congruency" and "Task" did not reach statistical significance in the noisy condition. Primarily, it is likely that the audio files accompanied by the noise created a relatively harsh environment for listeners to make their responses quickly. Unlike in the quiet condition where listeners could rely on the integrated prosody of words to identify emotions, they were probably forced to hear every syllable with much more effort to do the same job. And for these second language learners, mishearing only one syllable under a noisy condition could lead to loss and confusion about the lexical meaning of the whole word in the semantic task. Thus, the prosody tasks did not appear to be as easy and convenient due to the impact of noise. The increased difficulty of both tasks posed challenges for listeners to allocate their limited attention and seek the optimal solutions.

Moreover, the perception of English speech under noisy conditions occupied many more cognitive resources, including WM and inhibitory ability (84). After all, having controlled for language skills, WM, and emotional intelligence, the better inhibitory ability still predicted higher problem-solving accuracy (85). Factors such as noisy environment and other languages can adversely affect the speech perception process, leading to an increased difficulty for full understanding and a longer time to decode what was heard accurately (86). Since adverse listening conditions impair the encoding of speech signals, which means listeners have to allocate processing resources to separated aspects (87). (88, 89) also pointed out that the perceptual load of the current task participants conducted determined the allocation of cognitive resources during the process of selective attention. If the perceptual load of the current task was relatively low, and only a part of the attention resources was consumed in the process, then the extra attention resources would spare automatically to process the distractive stimuli, thus producing the distractive effect. On the contrary, if the perceptual load of the current task was high and the limited attention resources

were exhausted at once, the distractible stimulation unrelated to the task could not be perceptually processed, so the distractor effect will not be produced. In all in, in the current experiment, the additional cognitive, linguistic, and perceptual resources to understand English speech in noise, heavily consumed an individual's cognitive resources, leading to less Stroop effect.

Limitations and Future Directions

There exist several limitations in the current study. First, the conclusions were limited to trait-depressive Chinese college students of age 18–26 years. Given the extensive distribution of this mentally impaired population of all age groups, data, and information of only a fraction of college students, with even indistinctive second language competence in hearing, might limit how we interpret the model. Whether the results mentioned above reflect the psychological features of more common people remains unclear. Thus, a larger size of participants with marked characteristics is highly needed to draw more compelling views, with the assessing scales being of high validity. Second, compared with some previous studies adopting the Stroop-like paradigm, this research only focused on the binary cross-channel contrasts of audio emotional stimuli (semantic vs. prosodic), without applying more access to communication channels and modalities (e.g., facial expressions, videos). For the experimental design, practical settings are highly feasible. For instance, more types of noises with effects of closer authentic communication simulation or even real-life environment (i.e., babble noise), diverse emotions with finer classification sharing across cultures (i.e., surprise, sarcasm), multiple approaches to keeping abreast of language and psychological research to comprehend the neurological basis (i.e., event-related potential measures). Finally, it would be beneficial for further investigations on the clinical group of MDD to apply the current findings to the clinical setting.

CONCLUSION

In summary, this current study investigated psychological mechanisms of English emotion word processing under the semantics–prosody Stroop effect paradigm in quiet and noisy listening backgrounds, with Chinese college students with trait depression as participants. It was proved that the high trait depression group showed evident bluntness toward emotions compared with the low trait depression group in emotion word processing. And the widely existed Stroop effect affects the emotion word processing automatically, regardless of participants' trait severity (i.e., high trait or low trait) and listening conditions (i.e., quiet or noisy). The results also showed that participants tended to be more affected by the Stroop effect when they conducted prosody tasks and recognized emotions than being affected in the semantic task and identified English word valence. However, such contrast was not observed with a background of speech-shaped noise, indicating the masking effect of noise on cognitive processing. Taken together, these findings provide evidence supporting the emotional processing deficit of high trait-depressive people and congruence-induced facilitation effect in widespread Stroop effect, which provide a reference on the cross-linguistic special group with multi-listening conditions for future studies and offer fairly basic evidence for clinical application of the trait depression.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the School of Foreign Languages, Hunan University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

FC conceived and designed the study, performed the statistical analysis, and offered the financial support. JL collected and analyzed the data, and wrote the first draft of the manuscript. GZ designed the study and interpreted the data. CG participated in the statistical analysis. All authors contributed to the article and approved the submitted version.

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Network Analysis of the Relationship Between Trait Depression and Impulsiveness Among Youth

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Objective: Both impulsiveness and trait depression are the trait-level risk factors for depressive symptoms. However, the two traits overlap and do not affect depressive symptoms independently. This study takes impulsiveness and trait depression into a whole construct, aiming to find the complex associations among all facets and explore their relative importance in a trait network. It can help us find the key facets that need consideration in preventing depression.

Materials and Methods: We used the Barratt Impulsiveness Scale (BIS) and Trait Depression Scale (T-DEP) as measuring tools, conducted network analysis, and applied the Graphic Least Absolute Shrinkage and Selection Operator (GLASSO) algorithm to estimate the network structure and compute the linkage and centrality indexes. The accuracy and stability of the indexes were estimated through bootstrapping. All the computations were performed by R script and packages.

Results: We found that "trait anhedonia" was connected with "non-planning" and "cognitive" impulsiveness, while "trait dysthymia" was connected with "motor" impulsiveness. "Cognitive" impulsiveness had a statistically significant higher expected influence than "motor" impulsiveness and had the trend to be dominant in the network. "Trait dysthymia" had a statistically significant higher bridge expected influence than "cognitive" impulsiveness and had the trend to be the key facet linking impulsiveness with trait depression. "Non-only children" had higher network global strength than "only children." All indexes were accurate and stable.

Conclusion: The present study confirms the complex associations among facets of trait depression and impulsiveness, finding that "cognitive" impulsiveness and "trait dysthymia" are the two key factors in the network. The results imply that different facets of impulsiveness should be considered respectively regarding anhedonia and dysthymia. "Cognitive" impulsiveness and "trait dysthymia" are critical to the prevention of depression.

Keywords: trait depression, impulsiveness, network analysis, facet, dysthymia, anhedonia, youth

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Abbreviations: BIS, Barratt impulsiveness scale; BIS-11-CV, Barratt impulsiveness scale 11th Chinese version; Non.I, non-planning impulsiveness of the BIS; Mot.I, motor impulsiveness of the BIS; Cog.I, cognitive impulsiveness of the BIS; ST-DEP, state trait depression scale; T-DEP, trait depression scale; Dys.T, trait dysthymia of the T-DEP; Anh.T, trait anhedonia of the T-DEP; SDS, self-rating depression scale; BDI, beck depression inventory; GGM, Gaussian graphical model; GLASSO, graphic least absolute shrinkage and selection operator; PCM, partial correlation model; SPL, short path length; CI, confidence interval; CS, correlation stability; SD, standard deviation; PRISMA, preferred reporting items for systematic reviews and meta-analyses.

INTRODUCTION

Impulsiveness is an important risk factor for several mental disorders, including depression (1–3). The causal effect of impulsiveness on depression is confirmed by a longitudinal study (3). This indicates that impulsiveness is a vulnerability to depression. However, as assessed by the big-five personality inventory, trait depression predicts depressive symptoms, while impulsiveness does not (4). Trait depression and impulsiveness are two correlated facets of the domain "Neuroticism" (5), which is also verified when the two traits are measured by independent scales (6). Consequently, we infer that impulsiveness does not predict depressive symptoms independently but acts as an overlapped vulnerability with trait depression. Therefore, it is necessary to put the two traits together rather than to view them as independent factors of depression. However, both impulsiveness and trait depression are complex concepts, including distinct facets. It is not clear enough which facets are dominant or how the two traits are correlated with each other on the facet level. This is critical to understand the trait basis of depression and to take proper measures for prevention.

There are different models of impulsiveness. In the neurocognitive domain, Fineberg et al. (7, 8) divided impulsiveness into the motor, disadvantageous decision-making, choice, and reflection. Barratt's model, in turn, regards impulsiveness as a trait and also includes neurocognitive-related components, which are widely used in studies. It divides impulsiveness into the following three facets: "non-planning," "motor," and "cognitive" (9) (refer to **Supplementary Table 1** for facets and definitions). Both Eysenck's personality model (10) and the big-five personality model (5) include a depressive trait component, but do not consider the core feature of depression, i.e., anhedonia. Spielberger's model divides depression into anhedonia (lack of pleasure) and dysthymia (existence of despondent mood) (11), which can well cover the core features of depression (12). Meanwhile, Spielberger's model includes both state and trait depression. Different from state depression which refers to depressive symptoms or emotions now, trait depression, which includes "trait anhedonia" and "trait dysthymia," represents general depressive feelings throughout a long period of time (11, 13).

There is evidence that various facets of impulsiveness are associated with depression. The self-reported facets, such as "urgency" (14–16), "lack of perseverance" (16), "inattention," "lack of planning," and "inability in controlling temper or behavior" (17), are positively correlated with depression. In addition, the behavioral-measured impulsive decision-making and disinhibition of response are significantly different in depressive participants compared to the control groups (2). However, the above studies do not consider trait-level depression and its facets.

Although there are few studies discussing the relationships between trait anhedonia and impulsiveness or between trait dysthymia and impulsiveness, existing evidence shows that state (or diagnosed) anhedonia and dysthymia are related to different kinds of impulsiveness. Some studies reveal that state anhedonia and impulsiveness are positively correlated (18, 19), while others find negative associations (20, 21). It may be due to the use of different concepts of impulsiveness [e.g., dysfunctional impulsiveness (19), impulsive personality (18), and delay discounting rate (20)]. The relationship between state dysthymia and impulsiveness is unknown with few studies discussing it. Nevertheless, there is evidence that state dysthymia co-occurs with borderline personality disorder (22, 23), which shows impulsive features. Above all, whether different facets of impulsiveness and trait depression are correlated is not clear.

We do not find any study discussing the relative importance of different facets of impulsiveness and trait depression. Therefore, we cannot come up with a hypothesis about which facet is dominant in the construct. However, there is indirect information about the associations between the facets of depression and impulsiveness. Reward processing impairment is one of the core features of anhedonia in depression (24). Depressive patients with anhedonia show reduced positive emotions for the future reward, which is explained as a lack of anticipatory pleasure (25). This symptom presents a kind of non-planning-for-the-future character, which is also included in Barratt's impulsiveness model (9). Mood distress, as one of the features of dysthymia, is related to cognitive control (26) that is associated with lacking cognitive or behavioral inhibition. This indicates that dysthymia may be correlated with another two factors of Barratt's model, namely, "motor" and "cognitive" (9).

Therefore, in the present study, we take Spielberger's state-trait depression model (11) and Barratt's impulsiveness model (9, 27) to explore the relative importance and complex relationship between the facets of trait depression and impulsiveness. Simultaneously, we are aiming to find the key facets that link the two traits and to explore whether the demographic variables can influence the whole correlation pattern and the total correlation strength of all the facets. Network analysis is a suitable method to cover both the analyses of intercorrelations (represented by edge weight) and relative importance (represented by centrality indexes) (28). It can also consider the linkage of one variable among two or more communities (29), compare the whole correlation patterns and the total correlation strength between different populations (30), and give clear visualized results (28). These are not what the traditional correlation analysis possesses. Therefore, we apply network analysis (28), which includes all the trait facets in a network with all facets as nodes and associations as edges, covering both the analyses of intercorrelations (represented by edge weight) and relative importance (represented by centrality indexes). According to the association pattern on the state (or diagnostic) level mentioned above, we hypothesize that "trait anhedonia" is more closely connected with "non-planning" impulsiveness, while "trait dysthymia" is more closely connected with "motor" and "cognitive" impulsiveness. Regarding the relative importance of the facets and the other study objectives, we refer to the posterior results.

MATERIALS AND METHODS

Participants

A total of 295 participants (female = 181, male = 113, not report gender = 1) who were under 40 years (mean = 20.71,

SD = 2.97) were recruited initially. All the participants were youth studying in academies or working in Chongqing, China. They completed a paper version of the Trait Depression Scale (T-DEP) and Barratt Impulsiveness Scale (BIS) under the instruction of surveyors. We rejected 21 participants because they reported psychopathological family history or clinical history. The valid sample contained 274 participants (female = 167, male = 106, not report = 1), aging from 17 to 34 years (mean = 20.70, SD = 3.01) (refer to **Table 1**). There were 10 participants who had missing values in the two scales (seven participants with one missing value and three participants with two missing values each) [refer to **Figure 1** for the PRISMA diagram (31) of the participants' recruitment process]. We addressed these missing values with multiple imputation. This imputation method generates two or more values for each missing value through a certain algorithm and creates several imputation datasets. Researchers choose one or took the average of all datasets for the analysis (32). In this study, we used R "mice" package (33), applying a predictive mean matching algorithm to process multiple imputations. There were one and five participants who had missing values in gender and "only child" variables, respectively. These participants were rejected when gender or "only child" was considered in the network comparisons.

Assessment

Trait Depression Scale

The Trait Depression Scale is a subscale of the State Trait Depression Scale (ST-DEP) developed by Charles D. Spielberger in 1995 (11). Unlike the Zung Self-Rating Depression Scale (SDS) (34) and Beck Depression Inventory (BDI) (35), it is used to measure one's long-term depressive emotion (trait) rather than the state within 1 or 2 weeks. In addition, ST-DEP neglects the items relevant to somatization, retaining the items reflecting cognition and emotion, which are divided into two facets in both the S-DEP and T-DEP, namely, euthymia and dysthymia. Euthymia is the "existence of positive affect," while dysthymia is the "existence of negative affect" (11). Given that the euthymia subscale is reversely scored, it represents "lack of positive affect," namely, "anhedonia." The scale consists of thirty-two items, with sixteen items each in the S-DEP and T-DEP. Of the sixteen items of the T-DEP, eight items represent anhedonia, and the other eight items represent dysthymia. The Chinese version was translated and revised by Lei et al. (36). The reliability and construct validity of both the S-DEP and T-DEP were demonstrated among samples from college students (36). In this study, the T-DEP was shown to be reliable, with McDonald's omega values of 0.910 (95% CI = [0.892, 0.928]) and 0.861 (95% CI = [0.831, 0.892]) in anhedonia and dysthymia subscales, respectively.

TABLE 1 | Demographic information and descriptive statistics.

	Mean ± SD	*n*	%
Age	20.70 ± 3.01		
Gender (male)		106	38.7
Gender (female)		167	60.9
Gender (not report)		1	0.4
Only child (yes)		117	42.7
Only child (non)		152	55.5
Only child (not report)		5	1.8
Left-behind child (yes)		68	24.8
Left-behind child (non)		206	75.2
BIS	73.12 ± 13.91		
Non.I	22.51 ± 6.03		
Mot.I	26.95 ± 5.76		
Cog.I	23.66 ± 5.11		
T-DEP	28.96 ± 7.81		
Anh.T	16.23 ± 4.88		
Dys.T	12.72 ± 3.85		

SD, standard deviation; n, number of the participants; only child, the only one alive child of his or her parents; left-behind child, not living together with his or her parents before 10 years of age; BIS, barratt impulsiveness scale; Non.I, non-planning impulsiveness of the BIS; Mot.I, motor impulsiveness of the BIS; Cog.I, cognitive impulsiveness of the BIS; T-DEP, trait depression scale; Anh.T, trait anhedonia of the T-DEP; Dys.T, trait dysthymia of the T-DEP.

Barratt Impulsiveness Scale

The Barratt Impulsiveness Scale was originally developed by Barratt (37). It has been widely used to evaluate impulsive traits and behavioral patterns of healthy individuals or those who have impulse control disorder, borderline personality disorder, or other relevant mental disorders (9). There are thirty items in BIS, which are divided into three subscales, namely, "non-planning," "motor," and "cognitive" impulsiveness, representing "lack of forethought," "acting without inhibition," and "acting without thinking," respectively. Li and Philips translated the 11th version of the BIS into Chinese (Barratt Impulsiveness Scale 11th Chinese version, BIS-11-CV) (38), and they retained six items, revised five items, and replaced nineteen items. The reliability and validity of the BIS-11-CV have been shown to be good among Chinese samples from communities and colleges (27). However, according to Li and Philips' study (38), Item 13 (one item for "non-planning" impulsiveness) is more likely a feature of "cognitive" impulsiveness, while Item 24 (one item for "cognitive" impulsiveness) is more likely a feature of "motor" impulsiveness. We accepted the conclusion in this study; thus, the BIS-11-CV had good reliability with a coefficient of internal consistency in the present sample. The McDonald's omega values of the three subscales were 0.872 (95% CI = [0.844, 0.900]), 0.836 (95% CI = [0.806, 0.867]), and 0.846 (95% CI = [0.812, 0.881]).

Statistical Analyses

Descriptive Statistics

Demographic information and descriptive statistics were analyzed using IBM SPSS Statistics version 20.0 (39).

Network Analyses

RStudio version 1.4 with R 4.0.4 was used to conduct the network analyses (40).

Network Estimation

Gaussian graphical model (GGM) (41) is the basic method of cross-sectional network analysis. Based on GGM, the partial

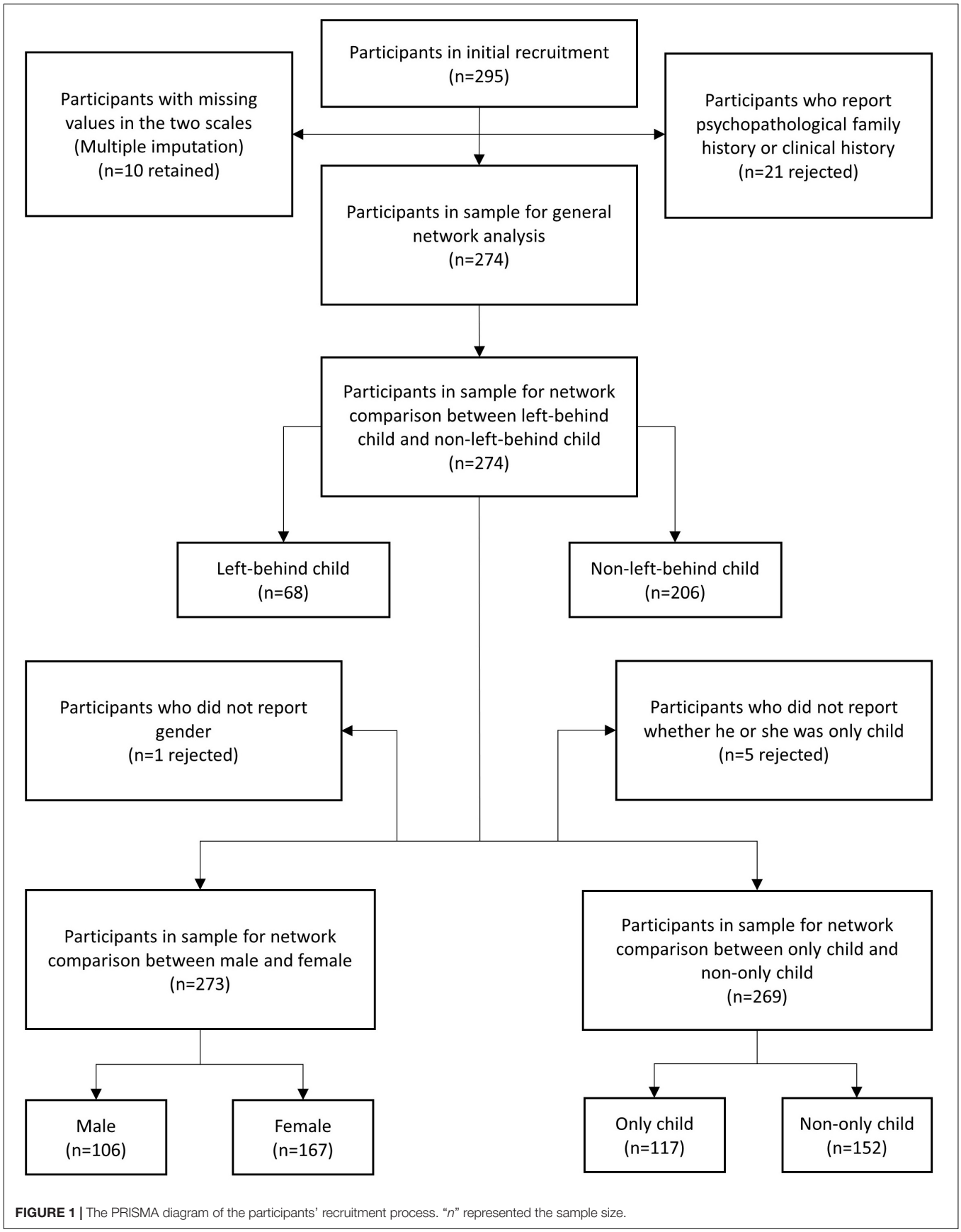

FIGURE 1 | The PRISMA diagram of the participants' recruitment process. "*n*" represented the sample size.

correlation model (PCM) (41) can eliminate spurious correlation. This study used the Graphic Least Absolute Shrinkage and Selection Operator (GLASSO) algorithm (42) to estimate the partial correlations of each observed variable, which could shrink the weak correlations to zero within the network to obtain a more stable network. The GLASSO algorithm was applied with the EBICglasso function of the R "qgraph" package (43). The network was visualized as nodes and edges of different colors and thicknesses. The red edges represent negative partial correlations, while the blue edges represent positive partial correlations. Thicker and darker edges represent stronger strength of correlations.

Centrality

Centrality represents the numbers, strength, and closeness of the correlations of one node with others in a network. The basic indexes of centrality are degree, closeness, and betweenness (43). Closeness and betweenness include "short path length, SPL" (28), considering all the direct and indirect correlations of one node with others, which allows the importance of the node to be evaluated. In the weighted network, the sum of weights of all edges of one node represents the centrality index, which is named "strength." Studies have shown the strength centrality to be more stable than closeness and betweenness (44, 45). However, for a network with both positive and negative edges, a previous study has shown that "expected influence," which is the sum of the value of all edges connecting to one node, is more appropriate (46). In the present study, the expected influence was chosen to represent the centrality index.

Stability and Accuracy Analyses

These two indexes were calculated by the R "bootnet" package (47). Because centrality statistics can be unreliable, accuracy and stability analyses were necessary. Therefore, the *post-hoc* stability and accuracy analyses were conducted. The 95% confidence intervals (95% CIs) were calculated for the accuracy of edge weights with bootstrapping. The narrower the 95% CI was, the more accurate the edge weights were. The recommended value of edge weight accuracy is not less than 0.5 (47). The stability of centrality indexes was estimated by calculating the correlation stability (CS) coefficient with case-dropping bootstrapping. The CS coefficient should not be lower than 0.25 and better be more than 0.5 (47).

Bridge

The Bridge indexes are usually used to describe overlapping nodes in studies on mental disorders (48). The bridge expected influence can indicate the risk of contagion among different disorders (29). In this study, the bridge expected influence was applied to illustrate the overlap of the two traits to prove that those who were vulnerable to depression had certain characteristics of impulsiveness. It was calculated by the R package "networktools" (49). The higher the bridge expected influence was, the greater the overlap was.

Network Comparison

To examine the effects of gender (male and female), "only child" (only child and non-only child), and "left-behind child" (left-behind child and non-left-behind child) on the network, we conducted network comparisons by the R "NetworkComparisonTest" package, applying permutation test to compare the network invariance (the network structure pattern) and the global strength invariance (the sum of the weight of the edges within the network) (30). The network comparisons for the three factors were performed, respectively.

RESULTS

Demographic Information and Descriptive Statistics

The demographic information and descriptive statistics are shown in **Table 1**.

Network Structure

The network of trait depression and impulsiveness is shown in **Figure 2**. Eight of ten possible connections were not zero. Within trait depression, "trait anhedonia" and "trait dysthymia" were closely connected, with an edge weight of 0.400. Within impulsiveness, "cognitive" impulsiveness was linked with "non-planning" and "motor" impulsiveness with the edge weights of 0.515 and 0.271, respectively, while "non-planning" and "motor" impulsiveness were connected, with an edge weight of 0.006. Between the two traits, "trait anhedonia" was related to "non-planning" impulsiveness (weight = 0.193) and "cognitive" impulsiveness (weight = 0.157), and "trait dysthymia" was connected with "motor" impulsiveness (weight = 0.309) and "non-planning" impulsiveness (weight = 0.089). Among these, the weights of the edges "Mot.I–Dys.T" and "Non.I–Dys.T" were neither significantly different (95% $CI_{bootstrap}$ = [−0.002, 0.459]) nor were the weights of the edges "Non.I–Anh.T" and "Cog.I–Anh.T" (95% $CI_{bootstrap}$ = [−0.301, 0.246]) (refer to **Table 2**). Meanwhile, the weight of the edge "Non.I–Cog.I" was significantly larger than those of "Mot.I–Cog.I" (95% $CI_{bootstrap}$ = [0.045, 0.454]) and "Non.I–Mot.I" (95% $CI_{bootstrap}$ = [0.258, 0.687]) (refer to **Table 2**). The weights of the edges "Cog.I–Dys.T" and "Mot.I–Anh.T" were shrunk to zero after applying the GLASSO algorithm, which indicated that these two linkages were of the least importance in this network.

Centrality

We used expected influence as the index of centrality. As shown in **Figure 3**, "Cog.I" had the highest expected influence values (the expected influence values are listed in **Table 3**), indicating that this node was the most important one in the network and had the strongest connections to other nodes. "Mot.I" had the lowest expected influence value, indicating that this node was the least important one in the network. However, the significance test showed that only the comparison between "Cog.I" and "Mot.I" was statistically significant (refer to **Table 3**).

Stability and Accuracy

The number of bootstrapping samples was 2,000 when calculating both the edge weight accuracy and the CS coefficient

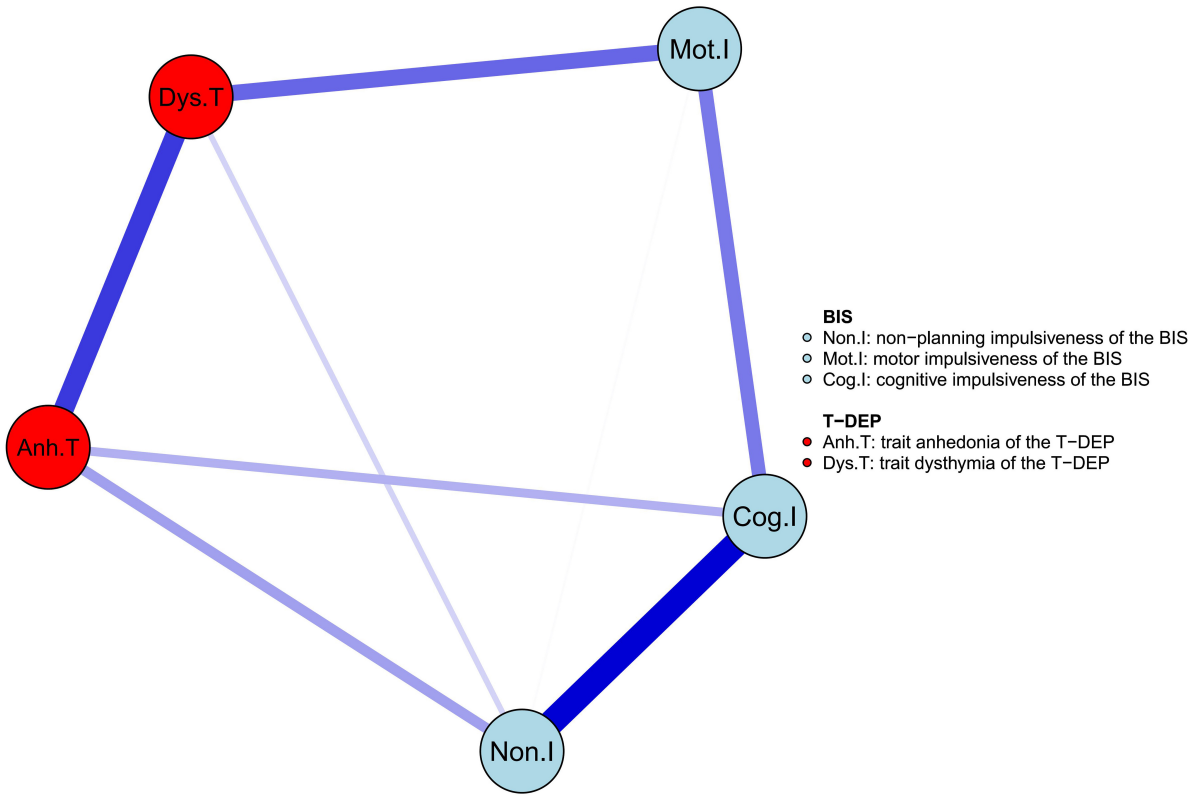

FIGURE 2 | The network structure of trait depression and impulsiveness in the youth. The edge weight values are listed in **Supplementary Table 2**.

of expected influence. In this network, the edge weight accuracy was 0.75 (the bootstrap mean of the edge weight is plotted in **Supplementary Figure 1**), higher than the recommended 0.5 (47). The CS coefficient of expected influence was 0.44 (the average correlation with the original sample for expected influence is plotted in **Supplementary Figure 2**), higher than the recommended 0.25 (47). These results indicate that the centrality statistics were stable and accurate.

Bridge

The bridge index is usually used in symptom networks to determine which symptoms have the greatest risk of contagion between two symptom groups. However, for personality networks, it can be applied to describe which trait components linked the different personalities closest. We regarded impulsiveness and trait depression as two communities when calculating the bridge expected influence values. The trait components were represented by facets (five facets in total). According to **Figure 4**, the most important bridge trait component was "trait dysthymia," and the bridge expected influence value of which was 0.398. However, only the difference between "trait dysthymia" and "cognitive" impulsiveness was significant (95% $CI_{bootstrap}$ = [0.011, 0.461]) (refer to **Table 4**) (the bridge expected influence values are listed in **Supplementary Table 4**). The CS coefficient of bridge expected influence was calculated with bootstrapping (n = 2,000), resulting in a value of 0.29 (the average correlation with the original sample for bridge expected influence is plotted in **Supplementary Figure 3**), which was higher than the recommended 0.25 (47). This indicates that the bridge centrality statistics were stable.

TABLE 2 | Edge weight comparisons.

Edge 1	Edge 2	95% $CI_{bootstrap}$ of Δ weight (edge 1–edge 2)	
		Lower	Upper
Mot.I–Dys.T	Non.I–Dys.T	–0.002	0.459
Cog.I–Anh.T	Non.I–Anh.T	–0.301	0.246
Non.I–Cog.I	Mot.I–Cog.I	0.045	0.454
Mot.I–Cog.I	Non.I–Mot.I	–0.036	0.457
Non.I–Cog.I	Non.I–Mot.I	0.258	0.687

Non.I, non-planning impulsiveness of the BIS; Mot.I, motor impulsiveness of the BIS; Cog.I, cognitive impulsiveness of the BIS; Anh.T, trait anhedonia of the T-DEP; Dys.T, trait dysthymia of the T-DEP; 95% $CI_{bootstrap}$, 95% confidence interval computed with the bootstrapping method. The level of significance test was alpha = 0.05 (corrected by Bonferroni correction).

Network Comparisons

We did not find differences between male and female in network invariance (M = 0.163, p = 0.614) or global strength (S = 0.238, male = 1.972, female = 2.211, p = 0.199). This indicates that gender does not affect the network structure pattern or

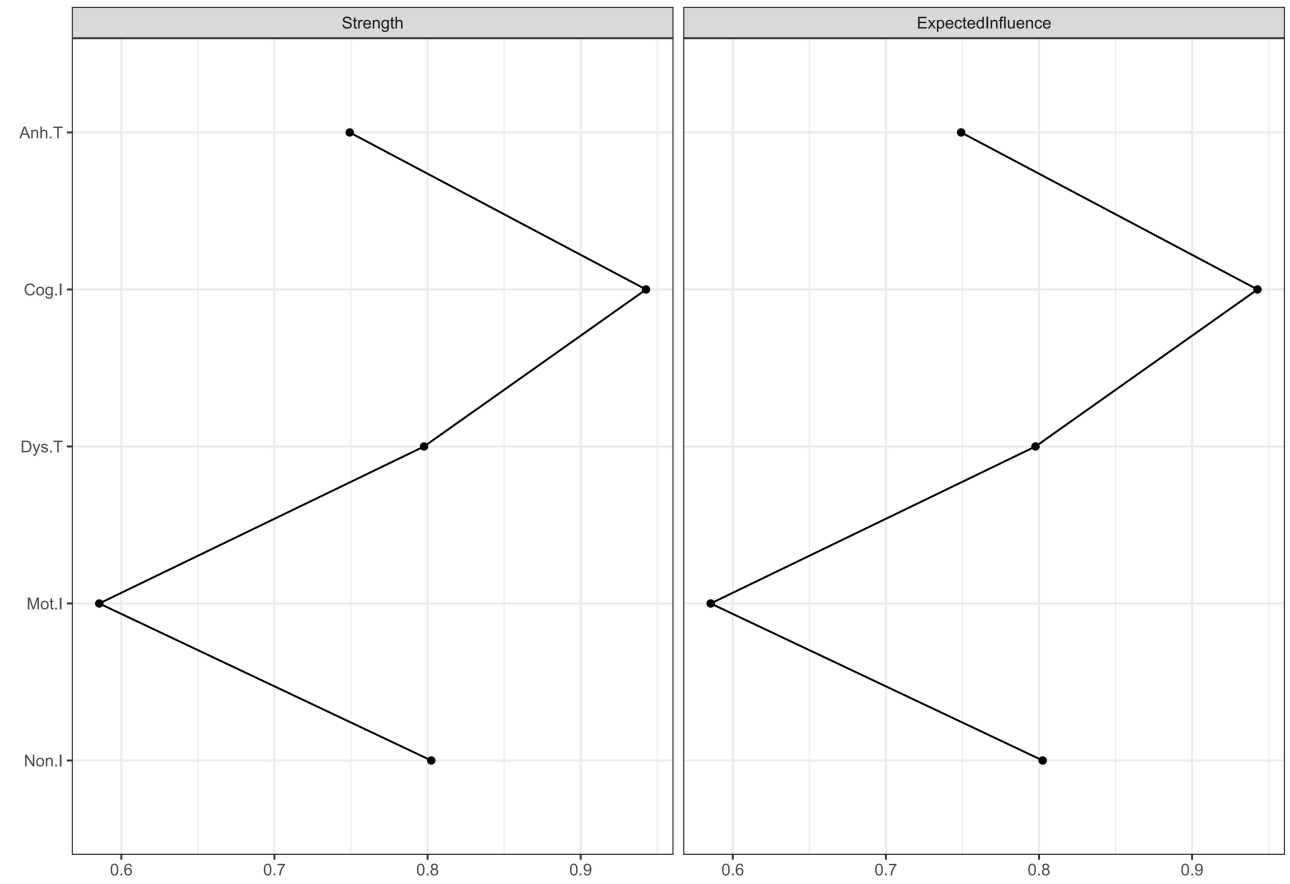

FIGURE 3 | Centrality plots of strength and expected influence. Because there was no negative edge weight in this network, the values of strength and expected influence were the same. The strength and expected influence values are listed in **Supplementary Table 3**.

connection strength. There were also no significant differences between the "left-behind child" group and the "non-left-behind child" group in network invariance (M = 0.233, p = 0.312) or global strength (S = 0.156, "left-behind child" = 1.827, "non-left-behind child" = 1.982, p = 0.438). However, although there was no significant difference between "only child" group and "non-only child" group in network invariance (M = 0.179, p = 0.487), we found a difference in global strength invariance (S = 0.408, "only child" = 1.889, "non-only child" = 2.297, p = 0.038). This result indicates that the "non-only child" group has a stronger global connection than the "only child" group among impulsiveness and trait depression facets.

DISCUSSION

In the present study, we adopted the network analysis method to explore the associations between different facets of trait depression (e.g., "trait anhedonia" and "trait dysthymia") and impulsiveness (e.g., "non-planning," "motor," and "cognitive" impulsiveness) and their relative importance. We demonstrate that "trait anhedonia" is connected with "non-planning" and "cognitive" impulsiveness but not with "motor" impulsiveness and that "trait dysthymia" is connected with "non-planning" and "motor" impulsiveness but not with "cognitive" impulsiveness. In addition, according to the expected influence, "cognitive" impulsiveness is the most important facet in the network, which can link other facets globally. Meanwhile, "trait dysthymia" is the most important facet linking trait depression with impulsiveness. Among the demographic variables, "only child" affects the network global strength, while "gender" and "left-behind child" do not, which indicates that the facets of trait depression and impulsiveness are more closely connected with each other in "non-only child" than in "only child."

Network Structure

As demonstrated in our hypothesis, what we mainly care about are the associations of the three facets of impulsiveness with "trait anhedonia" and "trait dysthymia." There are two disagreements between the results and the hypothesis. First, "cognitive" impulsiveness is connected with "trait anhedonia" rather than "trait dysthymia." The cognitive component of impulsiveness mentioned earlier is measured by a behavioral task, which mainly refers to error-related brain activities. However, in this study, "cognitive" impulsiveness is measured by a self-report questionnaire, which represents a more general impulsive

TABLE 3 | Expected influence comparisons of each node.

Node 1	Node 2	95% $CI_{bootstrap}$ of Δ expected influence (node 1–node 2)	
		Lower	Upper
Cog.I	Mot.I	0.083	0.667
Non.I	Cog.I	–0.503	0.228
Dys.T	Cog.I	–0.451	0.151
Anh.T	Cog.I	–0.556	0.094
Non.I	Mot.I	–0.032	0.507
Dys.T	Mot.I	–0.011	0.520
Anh.T	Mot.I	–0.081	0.436
Dys.T	Non.I	–0.278	0.251
Anh.T	Non.I	–0.436	0.202
Anh.T	Dys.T	–0.413	0.224

Non.I, non-planning impulsiveness of the BIS; Mot.I, motor impulsiveness of the BIS; Cog.I, cognitive impulsiveness of the BIS; Anh.T, trait anhedonia of the T-DEP; Dys.T, trait dysthymia of the T-DEP; 95% $CI_{bootstrap}$, 95% confidence interval computed with the bootstrapping method. The level of significance test was alpha = 0.05 (corrected by Bonferroni correction).

cognitive process (not thinking thoroughly before action). In addition, the correlation between anhedonia and the cognitive component of impulsiveness is confirmed in a study, in which "cognitive" is directly measured by brain functional imaging (50). Second, "non-planning" impulsiveness is connected not only with "trait anhedonia" but also with "trait dysthymia." There may be two possible explanations for this result. One is that both "trait anhedonia" and "trait dysthymia" have unmotivating components, which can be observed from the item meanings of T-DEP (36). Another is that "non-planning" impulsiveness includes both unmotivating components that are related to "trait anhedonia" and other components that may be related to "trait dysthymia." The result that "non-planning" impulsiveness is connected with "trait anhedonia" agrees with the result of a previous study, considering the non-planning reward process and anhedonia symptoms (50). However, the relationship between "trait dysthymia" and the "non-planning" impulsiveness needs further consideration in the future.

The connection between "trait dysthymia" and "motor" impulsiveness confirms the hypothesis. The positive linkage between "motor" impulsiveness and "trait dysthymia" agrees with the result of a previous study, showing that dysthymic symptoms are related to cognitive control evaluated by behavioral measurement and ERN (26) because behavioral measuring of cognitive control includes behavioral inhibition component that is the feature of "motor" impulsiveness. The connections between "trait dysthymia" and "non-planning" impulsiveness and between "trait dysthymia" and "motor" impulsiveness are not significantly different. However, the edge weight of "trait dysthymia—motor impulsiveness" has a trend to be larger (refer to **Table 2**). These findings indicate that "trait dysthymia" tends to be mainly linked with "motor" impulsiveness.

In conclusion, we tend to believe that "non-planning" and "cognitive" impulsiveness are the trait features of anhedonia and "motor" impulsiveness is the trait feature of dysthymia.

In addition, within trait depression, "trait anhedonia" and "trait dysthymia" are closely linked with each other. This indicates that trait depression seems to be an integral construct, which agrees with the description in DSM-5 (51) that anhedonia and dysthymia are the two cardinal symptoms of major depressive disorder. However, within impulsiveness, the association between "non-planning" and "cognitive" impulsiveness is stronger compared with the other two associations. This may be because "non-planning" and "cognitive" impulsiveness are mainly cognitive features, while "motor" impulsiveness is mainly a behavioral feature (9). Therefore, impulsiveness seems not to be a simple structure.

Expected Influence

The expected influence reveals the importance of each trait facet (46). The five trait facets are included in a single structure, which may be regarded as the vulnerable personality for depressive disorder. "Cognitive" impulsiveness is a relatively more important facet in this study. This indicates that it is connected with other facets more widely or more closely. "Cognitive" impulsiveness represents quick thinking without inhibition (38), which is a stable feature of cognitive processing. The results infer that the cognitive feature of impulsiveness may be the core factor. It agrees with the cognitive hypothesis of depression (52). "Motor" impulsiveness is the least important facet in this structure. This indicates that "motor" impulsiveness only composes a small part of the vulnerability to depression. One possible reason is that "motor" impulsiveness includes fewer cognitive components than the other two impulsiveness facets (38). However, the cognitive component is an important factor in depression (52). Another possible reason is that "motor" impulsiveness, defined as impaired behavioral inhibition (9), is included in the behavioral inhibition system that has a weak correlation with anhedonia (53). The other three facets (e.g., "non-planning" impulsiveness, "trait anhedonia," and "trait dysthymia") have no significant difference in relative importance from neither "cognitive" impulsiveness nor "motor" impulsiveness. This result reveals that "cognitive" impulsiveness only has a significantly larger weight than "motor" impulsiveness, which indicates that none of the five facets is statistically dominant in this network. Nevertheless, "cognitive" impulsiveness has the trend to be dominant.

Bridge Expected Influence

Regarding trait depression and impulsiveness as two different systems, we use the bridge index (48) to find the common components between them. "Trait dysthymia" is a common component that links trait depression with impulsiveness. A possible explanation is that "trait dysthymia," as a habitual mood distress feature, could be affected by the inability of controlling temper and behavior (9). "Cognitive" impulsiveness has the lowest bridge expected influence, despite its highest expected influence. This indicates that it less directly links with "trait dysthymia" and "trait anhedonia" but through other trait facets. The bridge expected influence of the other three facets (e.g., "trait anhedonia," "motor" impulsiveness, and "non-planning" impulsiveness) has no significant difference from neither "cognitive" impulsiveness nor "trait dysthymia," which indicates that none of the five facets is statistically more

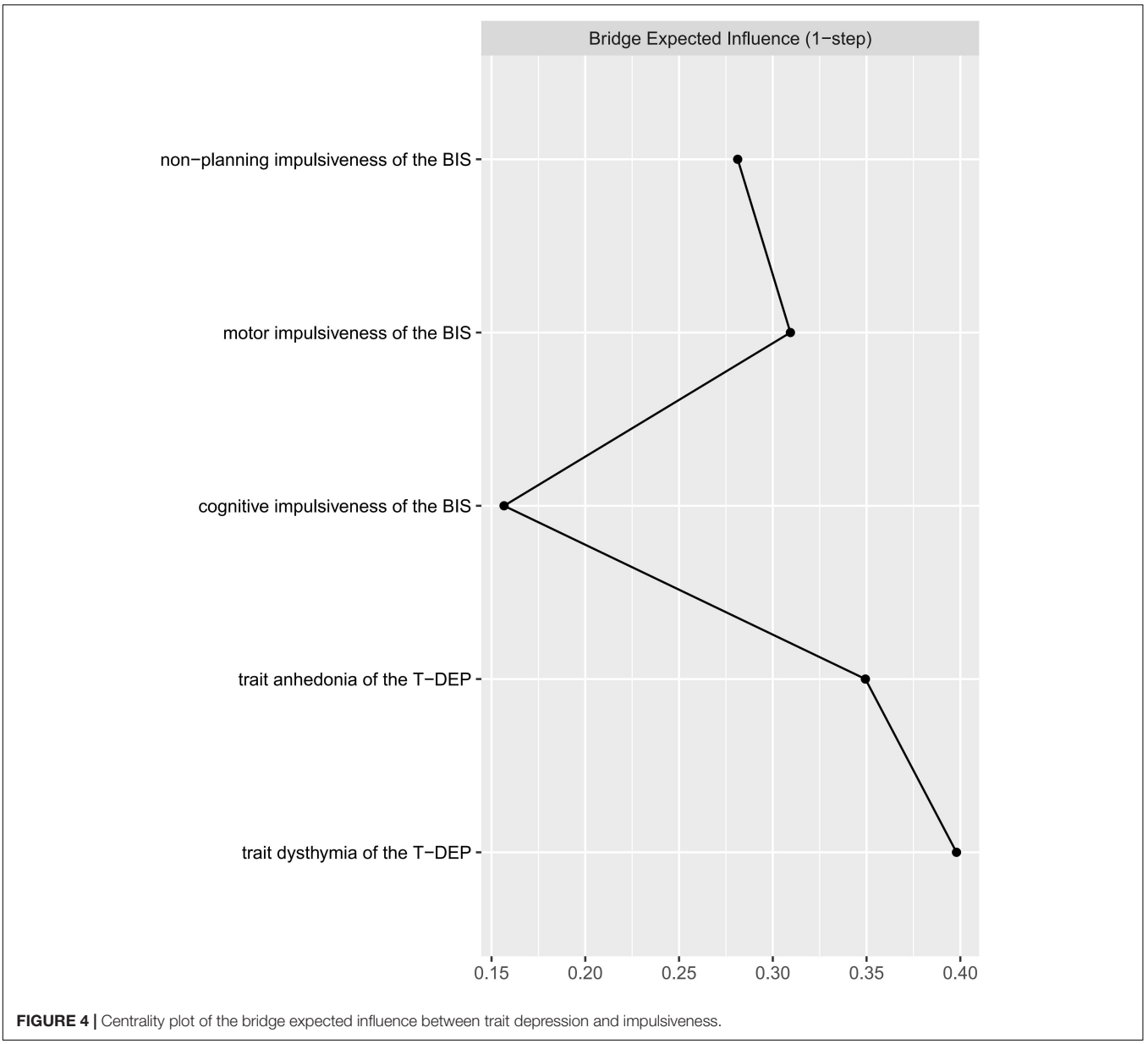

FIGURE 4 | Centrality plot of the bridge expected influence between trait depression and impulsiveness.

important than others in linking impulsiveness with trait depression. However, "trait dysthymia" has the trend to be the most important facet bridging the two traits.

Network Comparisons

The results of the network comparisons show that gender, "only child," and "left-behind child" does not affect the network structure. Previous studies have revealed that gender (54), "only child" (55), and "left-behind child" (56) are the factors that affect the prevalence of depressive symptoms. However, the present study mainly focuses on the inner correlation pattern. This may lead to the non-significant effects of demographic variables on network structure. Global strength represents the degree of associations among the facets of trait depression and impulsiveness. In previous studies, gender's effects on the association between impulsiveness and depressive symptoms are inconsistent. Some of them report significant effects (57, 58) but others do not (59, 60). In the present study, gender does not affect global strength, which agrees with the non-significant results of the previous studies. Further studies are needed to figure out whether gender's non-significant effect on the global strength of the associations among the facets of impulsiveness and depression is stable across symptom-level and trait-level. To the best of our knowledge, although there are studies exploring the effect of "only child" and "left-behind child" on depression (55, 56), few consider their influences on the association between impulsiveness and depression. Both "only child" and "left-behind child" include the factor of childhood experience, which is the basis of personality formation and development (61, 62). In our study, "only child" does influence the global strength of this

TABLE 4 | Bridge expected influence comparisons of each node.

Node 1	Node 2	95% $CI_{bootstrap}$ of Δ bridge expected influence (node 1–node 2)	
		Lower	Upper
Cog.I	Mot.I	–0.347	0.172
Non.I	Cog.I	–0.168	0.377
Dys.T	Cog.I	0.011	0.461
Anh.T	Cog.I	–0.094	0.380
Non.I	Mot.I	–0.269	0.253
Dys.T	Mot.I	–0.072	0.336
Anh.T	Mot.I	–0.162	0.262
Dys.T	Non.I	–0.077	0.345
Anh.T	Non.I	–0.199	0.263
Anh.T	Dys.T	–0.425	0.200

Non.I, non-planning impulsiveness of the BIS; Mot.I, motor impulsiveness of the BIS; Cog.I, cognitive impulsiveness of the BIS; Anh.T, trait anhedonia of the T-DEP; Dys.T, trait dysthymia of the T-DEP; 95% $CI_{bootstrap}$, 95% confidence interval computed with the bootstrapping method. The level of significance test was alpha = 0.05 (corrected by Bonferroni correction).

personality network but "left-behind child" does not. This may be due to the psychosocial confounders (e.g., parenting pattern and family structure), which we have not taken into consideration.

Implications

Above all, the results indicate that "cognitive" impulsiveness is an underlying feature, while "trait dysthymia" is a key feature that links impulsiveness with trait depression. For the prevention of depression, it seems that "cognitive" impulsiveness needs more consideration because it widely influences the whole vulnerability network. "Trait dysthymia" needs more attention when considering the reciprocal effects of impulsiveness and trait depression. A better intervention of "trait dysthymia" may reduce the likelihood of the co-existence of trait depression and impulsiveness, which can decrease the risk of the aftermath led by depression and impulsiveness together (e.g., suicide). When considering the subtypes of depression, dysthymia needs more attention on both "trait dysthymia" and "motor" impulsiveness, while anhedonia needs more attention on "trait anhedonia," "cognitive," and "non-planning" impulsiveness. In addition, "non-only children" need more attention in the prevention of depression, because they are more possible to have both impulsiveness and trait depression than "only children."

Limitations

There are some limitations to this study. First, the sample comprised college students and residents in Chongqing, China. It is unknown whether the results can be expanded to a wider sample. Second, the data were collected in a cross-sectional manner before morbidity, which was not sufficient to determine whether the network is on trait level. Third, some psychosocial confounders were not taken into consideration, which might affect the network structure and strength. In the future, depressive populations in the premorbid, state, and remitted stages can all be recruited. The relations existing across the three stages would be stronger evidence for the trait hypothesis. More participants need to be recruited from different areas and ethnicities. More psychosocial factors that may influence personality can be included to reduce bias.

CONCLUSION

The present study confirms the correlation between trait depression and impulsiveness personality, finding that "trait anhedonia" is associated with "non-planning" and "cognitive" impulsiveness, while "trait dysthymia" is associated with "motor" impulsiveness. Therefore, in the prevention of depression, different aspects of impulsiveness should be considered respectively regarding anhedonia and dysthymia. In addition, "cognitive" impulsiveness is an underlying feature of the vulnerability to depression, and "trait dysthymia" is a key factor linking impulsiveness with trait depression. Therefore, "cognitive" impulsiveness and "trait dysthymia" are critical to the prevention of depression.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Medical Ethics Committee of Army Medical University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JZ contributed to the design of the research, conducting a questionnaire survey and statistical analyses, and drafting the manuscript. KL contributed to the questionnaire survey, writing the R script, and revising the manuscript. YX contributed to the questionnaire survey, arranging the raw data, and performing statistical analyses. ZF contributed to the design of the whole study and the critical revision of the manuscript. All authors have read and revised the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.916332/full#supplementary-material

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Nurses experience of caring for patients with COVID-19: A phenomenological study

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Introduction: COVID-19 has impacted all dimensions of life and imposed serious threat on humankind.

Background: In Jordan, understanding how nurses experienced providing care for patients with COVID-19 offers a framework of knowledge about similar situations within the context of Arabic culture.

Aim: To explore nurses' experience with providing hands-on care to patients with active COVID-19 infection in an Arabic society.

Methods: A descriptive phenomenological study interviewed 10 nurses through a purposive sampling approach until data saturation was reached. The research site was hospital designated to receive patients with active COVID-19 infection. Semi-structured interviews were used to collect the data.

Findings: Three themes were generated from the data: the impact of the COVID-19 outbreak on nurses' health; unfamiliar work and social environments; and conforming to professional standards.

Discussion: There are specific risks to the physical and mental wellbeing of nurses who provide hands-on care to patients with COVID-19 in an Arabic society.

Implication for nursing and health policy: Health care institutions should consider establishing programs that promote nurses' wellbeing and support their productivity in a crisis. A danger pay allowance should be considered for nurses during extraordinary circumstances, such as pandemics.

KEYWORDS

nurses, experience, caring, COVID-19, collectivist, a phenomenological study, Arabic culture, Jordan

Introduction

The novel coronavirus-2 (SARS-CoV-2) virus emerged in Wuhan in late December 2019 and was declared as a pandemic by the World Health Organization (WHO) early in March 2020, and is the most serious virus outbreak yet in the 21st century (1). It has placed the global health care system and health workforce under unprecedented pressure. Health care systems worldwide have failed to provide effective preventive measures and management plans to contain the pandemic (2). This has promoted feelings of uncertainty among health care professionals, specifically nurses.

Nurses spend more time with patients than any other health care team; hence, it is plausible that they are at higher risk for attracting and transmitting the disease (3). The nature of the SARS-CoV-2 virus including its incubation period, mode of transmission, and infectivity emphasized the continuity of the threat and risk to nurses' health, justifying feelings of uncertainty and mental health concerns (4, 5).

COVID-19 outbreak has raised levels of stress, anxiety and depression among nurses. Recent studies from China (5–7) and Italy (8), the first two regions to be impacted by this disease, reported that nurses who delivered hands-on care for patients with COVID-19 were at higher risk of developing mental health disorders compared with other health care providers. Furthermore, a study by Rossi et al. (8), which included 1,379 health care providers, of which one-third were nurses, reported that having a co-worker who suffered from COVID-19 was a significant factor that exacerbated mental health problems among nurses.

Background

In collectivist communities the dimensions of care are bound by the nature of the social norm, for example, family members who work as health care providers are obliged to provide care for their relatives who suffer an illness, even if there is a concurrent, potentially deadly, health threat like COVID-19. All aforementioned features of the SARS-CoV-2 virus and the nature of the Arabic cultural norms increase the susceptibility of nurses and other health care workers to the virus, thereby negatively impacting their mental health status (9, 10). For example, a collective social norm mandates that nurses who have a relative with COVID-19 should provide care for them and dedicate their time for the family, because a family's interest comes first.

Like other countries, Jordan had suffered from the COVID-19 pandemic, which has caused a wide range of physical, social, psychological and economic implications. Case zero in Jordan was reported on 2 March 2020 in the capital city of Amman, with the first COVID-19 carrier being a traveler from Italy (11). Thereafter, the incidence curve increased slightly and then plateaued, during which the Jordanian health authorities reported low incidence levels ranging from one case in the beginning of March 2020 to 68 cases in mid-August 2020. Afterwards, the curve started showing an upward trend, with the number of confirmed cases increasing significantly to 7,933, among whom 60 had died (1), including 29 health care providers (12). Although the Jordanian health authorities had a 7-month window (March–November) to enhance the health care system preparedness for this pandemic, progress remained slow. Two studies assessed nurses' reactions to COVID-19 in Jordan (9, 10). Al-Amer et al. (10) study recruited around 400 nurses using an online survey, and found a high prevalence of depression, anxiety and stress among the study participants. Abuhammad et al. (9) study identified nine Facebook nursing groups in Jordan and evaluated their accounts regarding their perception of their roles during COVID-19. Both studies were conducted between March and April 2020 when the number of cases ranged between 1 to 22 cases daily.

Few qualitative studies have investigated nurses' perception regarding the care for patients with COVID-19, particularly those with active symptoms. To our knowledge, no studies have considered how perceptions might differ for nurses living and working in a collectivist society such as the Jordanian's. Hence, understanding nurses' perception and experience in relation to the current pandemic situation carries substantial value. The present study is the first to explore the experiences of Jordanian nurses in the face of the COVID-19 pandemic. Hence, the study was guided by the following research question "What was the lived experience by Jordanian nurses caring for Patients with COVID-19 like?"

Aim

In this research, we aimed to describe the experience of providing hands-on care to patients with COVID-19 from the accounts of nurses in Jordan which is a collectivist society. The term "active COVID-19" was conceptualized to refer to any person who tested positive for SARS-CoV-2 and exhibited symptoms that warranted hospital admission.

Methods

Study design

This study used the descriptive phenomenological approach by Husserl (13). According to Husserl, the phenomenon should be allowed to speak for itself through the voices of people. Husserl's (14) philosophy states that researchers must "bracket" any prior knowledge, preconceived notions, and judgements about the phenomenon of interest before data collection to avoid influencing outcomes (15). The researchers who collected

and analyzed the data practiced phenomenological reduction by asking themselves a series of questions.

Sample and setting

Using purposive sampling, 10 nurses who provided hands-on care for patients with active COVID-19 were approached. The purposive sampling technique was deemed suitable for this study because the data source was a closed fit to deliver data that would answer the study-related research question (16, 17). Nurses providing hands-on care for patients with COVID-19 are the most experienced and will be informed about this phenomenon. Thus, they were recruited to reflect the expert experience that can deliver data relevant to the research inquiries (18).

The study populations were all nurses and recruited from major hospitals in Amman that were designated for treating patients with COVID-19. The inclusion criteria for the study subjects were being a registered nurse providing hands-on care for patients with active COVID-19 infection at least a month prior to the data collection procedure, and willing to participate in this study. The study excluded associate nurses because their duty of care is limited to specific procedures, for example, they were not allowed to administer medications, and the study aimed to have participants that could reflect on the whole experience of caring for patients with COVID-19. The sample size was determined based on the saturation, which took place on the 10th participant when the collected data held no new additional findings (19).

Data collection

The first author, who has a PhD in nursing and experience in conducting qualitative interviews collected the data using a semi-structured interview guide developed by the first and last author based on available literature (Box 1). The guide was piloted among two nurses and subsequently, slight modifications were made, bearing in mind that the two-pilot interviews were excluded from the final report because it aimed to improve interview schedules and specific questions. Literature have reported that pilot study in qualitative research could identify several challenges for researchers such as but not limited to the "instrumentation rigor" and management of bias (20, 21). Piloting the interview guide was an important step toward the decision that the data collection should be conducted using a telephone-based approach, rather than in person as was originally proposed. In the pilot, wearing face masks made establishing a rapport with the participants difficult because the masks concealed our identities. We tried to overcome this barrier by disclosing some information about our families because in collectivist communities, individuals would be honored and more accepting if their families have good reputations. Additionally, during the interviews, the participants displayed hospitality by providing food, which should not be refused; thus, we felt that this might harm us or harm our participants. Accordingly, we committed to uphold "non-maleficence," as the wellbeing of the researchers, the community and the participants were a priority, and switched our approach to telephone-based interviews. It is important to note that COVID-19 has necessitated innovation in a wide range of dimensions of our lives—and research is no exception. For example, in qualitative research paradigm, face-to-face interviews were considered the "gold standard" approach to collecting data (17, 18, 22). However, during the COVID-19 pandemic, the face-to-face interview approach has encountered many constraints of social distancing and the prioritization of participants' and researchers' safety (23). Conducting qualitative interviews using a telephone approach offered researchers the opportunity to study the contexts of crisis while safeguarding participants and researchers (Roberts et al., 2021). However, telephone interviews could restrict the establishment of rapport between the researcher and the respondents which in turn could influence the richness of the data (22).

Ethics approval was granted by Isra University Human Research Ethics Committee/ethics approval number (JS/BA/94). Then an invitation was sent out to hospitals where patients with COVID-19 were treated. Hospitals that agreed to participate were asked to provide the research team with their nurse's email addresses, after which emails introducing the research team and the purpose of this study were sent to the nurses through hospitals "nursing departments" emails. Nurses who replied and fulfilled the inclusion criteria were contacted and sent a detailed participant information sheet and consent form. Signed consent was returned *via* email. The interviews, arranged at mutually convenient times, were semi-structured with pre-determined but open-ended questions that required rigor in the topics addressed but allowed flexibility in the exchange. The participants were advised that they could stop the interview at any point, and informed that the interview would be recorded using the "Voice Memos" mobile application for data collection and quality assurance purposes. Two nurses did not agree to their interview being recorded, prompting the first author to take down notes instead. Each interview lasted between 40 and 50 min.

The first author who is a female and shared the participants' language and culture conducted the interviews which facilitated establishing rapport with the participants. Participants were asked to narrate their experiences with providing hands-on care to patients with active COVID-19 (using their own words). Afterwards, each interview was transcribed verbatim. Another author reviewed and checked each transcribed interview against the audio materials. Identifying information was removed and participants were allocated a code. The reporting of data in this study has been performed according to the COREQ

BOX 1
Participants interview guide

- Can you tell me your experience of providing hands-on-care for a COVID-19 patient since the advent of the pandemic?
- Can you share with me an experience that of significance to you during providing hands-on-care for a COVID-19 patient?
- Please describe a day in which you were taking care of a COVID-19 patients.
- Please share me how do you see yourself as "a nurse" during this pandemic.

guidelines. All interviews took place between November and December 2020.

Data analysis

Data collection and analysis occurred concurrently and provided "rich" quality rather than "thick" quantity of data (24). Three of the researchers convened after the analysis of each interview to validate the analytical process. Data analysis were performed manually and was guided by Colaizzi (25) framework for phenomenological data analysis, which included the following steps: (a) familiarization; the researcher read each interview transcript several times to familiarize themselves with the data; (b) identifying significant statements; all statements in the narrative that had direct relevance to providing care for patients with COVID-19 were identified; (c) Formulating meanings; meaning relevant to the studied phenomenon was extracted from a careful attention of important statements. (d) significant statements and identified meanings across all interviews were grouped into themes (e) exhaustive description was generated in which the researchers have written a complete and a comprehensive description of the phenomenon under study where all the themes were included; (f) the researchers then consolidated the exhaustive description into a short, and dense statement that weas important to the phenomenon under study and the basic structure was constructed; (g) the researcher validated the study findings by the participants. Afterwards, quotes were provided to support the themes.

Rigor

This study maintained the trustworthiness of the data based on the criteria established by Lincoln and Guba (26), including credibility, transferability, dependability, and conformability. The credibility of data was ensured by "member checking" in which we have sent interviews transcripts to the participants for validation, however; only seven of them have responded. Also, the credibility was enhanced by the co-analyses that was jointly conducted by three of the research team. Also, this study provided a thick description of the context, the participants' characteristics, the settings, and the data collection procedure to maintain transferability. Dependability was ensured for the researcher kept a reflexive journal throughout the study and the data analysis process (27), Confirmability was confirmed by keeping a careful record" an audit trail" which includes the original notes, transcription and the analysis to preserve confirmability.

Findings

Participant characteristics

Ten nurses aged 27–45 years participated in the study (six were female), two contracted COVID-19 (one male and one female), nine had a bachelor's degree and one had a master's degree. Participants' experience as registered nurses ranged between 1 and 15 years.

Three major themes were obtained by the researchers through the analysis: The impact of the COVID-19 pandemic on nurses' health; Unfamiliar work and social environments; and conforming to professional standards.

Theme 1: The impact of the COVID-19 pandemic on nurses' health: "I am at a huge risk of getting infected and ending up in the ICU and dying"

Nurses strongly perceived COVID-19 as a deadly disease that negatively impacted their physical and psychological health. Moreover, they were uncertain regarding how this virus would behave. They felt they were at greater risk of infection,

> *"I did not recognize my friend when he got it, I am too afraid, no strong treatment for it [G]*

Three of the participants felt that COVID-19 was a serious physical threat, not only to them, but also to others around them, given that they might become potential agents of transmission:

> *"I moved my daughter to my mother-in-law's place because my wife and I are both working. There will be a chance she will end up being a COVID-19 patient because of us." [H]*

The threat posed by this virus included physical implications and psychological difficulties. Eight of the participants felt

that the health of their patients did not improve and instead deteriorated. They felt depressed about the situation and uncertain about their own health:

"I feel helpless and depressed. No matter what I do, the results are not encouraging; people dying every day, few of them made it." [M]

When health care workers became infected and exhibited active symptoms that required intensive care and ventilator support, participants expressed having experienced some form of physical pain, somatisation and helplessness. Six of the study participants remarked that seeing a colleague infected with COVID-19, being on ventilator was most depressing.

"It was depressing to see one of the anaesthesiologists connected to the ventilator, I (felt) a crushing sensation on my chest. I could not do anything." [A]

Most participants remarked that they were stressed, anxious and scared from the uncertainty and often used the phrase "what if," alongside their fear of transmitting it to their families.

"I keep on thinking, what if I got infected or transmitted the disease to my family; this causes me anxiety and stress; I can't run from such thoughts." [R]

Having a family member who got infected brought up severe psychological reactions that were compounded by guilt. The nurses involved assumed that they were the source of this infection and felt extremely depressed:

"When my father got infected with COVID-19, I was badly depressed I kept on blaming myself. What if my father dies?" [M]

Being asymptomatic would not help health care providers escape blame, shame and stigma. However, the participants admitted that these were the features of this pandemic:

"I personally got infected with COVID-19 on 21 October 2020. Three days before I knew I had corona, I visited my uncle. On 24 October, he had symptoms, and he has been on oxygen therapy. He kept on calling me and telling me that I have infected him, as if I am to be blamed. I did not know I had corona when I visited him, and the whole family were stigmatizing me as a person who transmitted it to others." [T]

Theme 2: Unfamiliar work and social environments: "Everything is changing in all dimensions; the workplace, and socially"

Nurses felt that COVID-19 had altered the work and social environment. COVID-19 was viewed as a disease that had implications on social relationships and interpersonal communication through their social life in general. All these changes were new to collectivist communities in which gatherings are main pillars of social life. Furthermore, nurses' workplaces experienced dramatic challenges that included the use of unfamiliar and limiting personal protective equipment (PPE) as the only protective measure against contracting the virus. Moreover, nurses had to address a wide range of new medical procedures and drugs.

Participants stated that they lacked PPE as well as the knowledge needed to provide quality care. No clear strategy or guideline had been established. Continuous changes in the treatment plan resulted in inefficient care:

"The lack of PPEs, the care we were providing were not anchored on a solid guideline. They changed the protocol many times, this will reduce the quality of care." [M]

They reported having to address new PPE measures, which had been portrayed as a physical and psychological burden on nurses; donning and doffing were a daily struggle.

"I personally put my PPEs on and change these PPE twice a day, I postpone everything that I need to do to a PPE-free slot once a day. It is very exhausting to keep donning and doffing." [G]

Four participants remarked that whilst wearing PPE during fasting for Ramadan, they experienced severe unbearable headaches, mainly due to dehydration:

"During Ramadan, I was fasting and had to wear the PPEs, and I felt thirsty because it is a hot outfit…after that I developed a headache, which affected my capacity to provide care." [N]

Masks and face shields were perceived as barriers to communication. Participants mentioned that patients often could not hear them clearly and would ask them to repeat their words multiple times:

"I got frustrated to repeat what I have just said, it was very difficult for me to connect with my patients, how a nurse would be able to build a relationship with patients." [Z]

All participants reported that patients felt frightened by nurses wearing PPE. It created a barrier that exacerbated loneliness, which could have resulted in severe anxiety and worries for patients and nurses. In addition, patients had difficulty in accepting personnel in PPE.

"My patients reported feeling lonely, they were not familiar with seeing nurses behind shields." [S]

Participants experienced unfamiliar social environments and reported that they encountered limitations when visiting their parents and elderly family members. The pandemic

prevented them from paying the utmost cultural respect to their parents. Participants said keeping distance from their parents or any elderly family members during normal conditions brought shame. However, they practiced social distancing and limited their visits to their parents, given that they were obliged by COVID-19 restrictions and wanted their parents to survive:

> *"It is hard to feel that you are trying to keep some social distancing with your parents. It is important to greet them with respect, hug them, kiss their hands and show them great admiration." [D]*

Theme 3: Conforming to professional standards: "This is my career, I should serve no matter what, and I have to care."

Although nurses were aware of the risk imposed by this pandemic and most of them remarked that they have suffered from physical and psychological stress, they were all committed to nursing ethics and continued to care for infected patients. They also stated that caring for infected patients was formed partly because of their religion, as well as the nature of their career.

> *"I am a Muslim; I do everything for God; I wanted my patients to get better so I can take care of the others who are on the waiting list." [H]*

However, all participants reported a time when they felt ambivalent toward providing care for infected patients, particularly when a shortage of PPE occurred, and some of the staff had contracted the virus. However, they continued to provide care and fight against COVID-19. They stated that they provided care and found a refuge in God for protection because of their good deeds:

> *"I had thoughts 'I am not a martyr,' but I felt this is not me, I am a person 'who accepted to be identified as a nurse,' so, I decided to act as a nurse in accordance with my career ethics." [Z]*

Some of the participants stated that caring for patients with COVID-19 had created an ethical dilemma: personal safety vs patient wellbeing. On the personal side, nurses were reluctant to provide care when PPE were lacking, and their safety was jeopardized. They argued that they had an ethical commitment toward their own safety and denied the widespread perception that nurses were born to be martyrs:

> *"I had a huge conflict and stress in me, but when they made the protective gears available for us, we did what our conscience required us to do, we cared." [N]*

Discussion

The current study aimed to explore how Jordanian nurses experienced providing care to patients with active COVID-19. In Jordan, work and family commitments are intertwined. Three themes were identified: the impact of COVID-19 on nurses' health; unfamiliar work and social environments; and conforming to professional standards.

COVID-19 has placed the nursing workforce across numerous countries under unprecedented pressure, which in turn has impacted their mental wellbeing (3). The current study supports previous literature which reported that nurses had a high level of depression, anxiety and stress during the COVID-19 pandemic (10) and viewed COVID-19 as a deadly disease (4–7). This could lead nurses to perceive COVID-19 as a disease with high fatality rate, hence, thinking of caring for infected patients as a burden. Nurses who provide care for patients of Arabic culture are more prone to mental health difficulties because such societies spend large amounts of time with their extended families and are not familiar with social distancing, specifically when it comes to their relatives (10).

The findings in the current study highlight the negative impact on participants' physical and psychological wellbeing. Some study participants experienced vicarious trauma after witnessing health care colleagues' sufferings and/or death from SARS-Cov-2 infection. This kind of trauma could be viewed as the "cost of caring" as nurses witness their colleagues suffering, this has resulted in psychological, and physiological difficulties. It appears that Jordanian nurses have become occupied with thoughts about their associates with COVID-19 infection. Similar findings were reported among Italian health care providers (8). Literature describes this as secondary traumatic stress syndrome (7). One participant described the threat to health in terms of actual physical pain of seeing colleagues being ventilated. We argue that nurses can live vicariously with the pandemic even when not infected with COVID-19. For example, repeated exposure to traumatic experiences could lead to vicarious trauma (28, 29), emotional distress and compassion fatigue (30, 31), which was also noted in nurses caring for COVID-19 patients (32). The relentless nature of the pandemic adds to this risk and was recognized by participants as being compounded by unfamiliar environments. These findings suggest that nursing leaders and policy makers need to pay more attention to the psychological capacity of nurses going forward.

Acute concern among nurses regarding the safety of their family members and the potential of transmitting the disease to their families was evident from the current study; this is understandable in light of the fact that nurses are responsible to promote their own health safety, and in Arabic community family's interest takes precedence on individual's benefits. Hence, nurses are required to balance their obligations of beneficence and duty to care for patients and duties to protect their loved ones. Prioritizing the wellbeing of family has been

reported as a barrier to health care workers' motivation to work in a pandemic (33). Although this was not evident in the present study, the effects of working during a pandemic emphasized the psychological distress experienced by our participants. This was further highlighted when one participant was blamed for the illness of a relative who contracted COVID-19. Several editorials have identified factors that would increase the propensity for a health care worker to develop mental health disorders during this outbreak, including fear of catching COVID-19 or transmitting it to a loved one (30, 34) and the high rates of associated mortality (34). Our study supports these commentaries. Our participants reported experiencing negative emotions when they witnessed the long-term suffering of their family members because of COVID-19.

Stresses at work can be mitigated by a healthy work–life balance. Having interests outside work, being able to socialize (35), and family and social support are important factors in reducing mental illness and burnout (36). In Arabic societies, the family is viewed as part of oneself. Thus, the pandemic negatively affected social norms on family inclusion. For example, in Arabic societies such as Jordan, the importance of family cannot be overstated. Large family gatherings and the social etiquette of hugging and kissing, especially with elderly relatives, has been considered a sign of utmost respect. Removing these facets of life that serve as a buffer against a challenging work environment as a result of pandemic measures (e.g., social distancing and lockdown), have added an additional layer of risk for Jordanian nurses to develop current and future mental health problems.

Wearing PPE was viewed as a barrier between the nurse and patient and negatively impacted communication with both patients and colleagues. This was plausible because verbal and non-verbal communication are both equally important in establishing rapport and trust. In line with our findings, McCarthy et al. (37) reported that wearing PPE hampered effective communication with patients, specifically among patients who were in isolation (37, 38). For example, the face mask has made non-verbal and verbal communication difficult. Face masks were also viewed as a physical barrier to empathy, which is essential in developing trust, a therapeutic relationship and effective communication between health care providers and patients because masks concealed their identity and facial expressions (39). Overall, PPE was found to conceal the role of a health care provider. For example, some patients had difficulty distinguishing a nurse from other health care providers, adding another barrier to effective communication and impacting patient–nurse relationships (37). However, we believe PPE are very important for patients and the nurses' health; in addition, employers are required to provide nurses with adequate PPE, and the institutions should be held accountable for any harm that affects nurses due to the lack PEE.

Nursing during COVID-19 has been recognized as a challenge to nurses' wellbeing (40). Our participants described changes in their work environments that caused additional work given that they were inexperienced and lacked education regarding the changes and how to appropriately manage them. In ordinary circumstances, strong leadership is expected to steer staff through change. A report by The King's Fund (41) stated that nurses and midwives have three core work needs: (1) autonomy (control over their work lives and ability to act consistently with their values); (2) belonging (the need to be connected to, cared for and be caring of others at work and to be respected, valued and supported); and (3) contribution (the need to be effective in their work and to deliver outcomes that are valued). Further recommendations suggest that commitment across health regulators, health improvement bodies and all partners in health and social care are required, that, alongside the core work needs, would ensure wellbeing and motivation at work and minimize stress (41). A framework such as this may be a valuable tool for supporting staff in future work environments as they recover from the COVID-19 pandemic and prepare for future challenges in the health sector.

Belonging (1) and contribution (3) (41) were evident in our participants responses under the theme "conforming to professional standards," Commitment to their professional and moral responsibilities as a nurse were clearly articulated. This may be explained in terms of the courage of compassion (41). A strong religious belief regarding what was right in this situation was also evident. However, despite their commitment and religious beliefs, participants did struggle with the ethical dilemma of balancing their responsibility to themselves and their family with the people in their care. The dilemma was exacerbated by the magnitude and uncertainty of the pandemic. Work overload, which was herein caused by COVID-19, has been reported as one reason for the occurrence of ethical dilemmas in nursing practice (42).

Conclusion

In exploring nurses' experiences of caring for COVID patients, we discovered that nurses working and living in a collectivist society, in which the work and social life are highly interconnected reported high levels of mental distress. Although nurses had suffered from physical, social, and mental difficulties, they were committed to providing patient care in which they conformed to their professional standards. The balancing act of managing personal wellbeing, societal expectations and professional commitments added to the impact of caring for COVID-19 patients in a collectivist society in which resources and health management structures to keep nurses safe were limited. The findings have implications for nursing and health policy.

Implications for nursing and health policy

Findings presented herein are significant in the context of being prepared for a situational crisis. This study has identified that nurses experienced risks to mental health because of COVID-19, hence, nursing leaders should develop ways to protect their staff from stress created in such situations. Health care institutions should consider establishing counseling programmes that promote nurses' mental health and support their productivity in a crisis, with specific emphasis on self-care activities The risk to health perceived by participants suggests that policymakers should have a plan in place to guide nurses in the present and future outbreaks. For instance, update nurses with all the current guidelines that are issued by health care bodies such as the (WHO) and provide them with all protective supplies to stay informed, productive and connected. Based on the findings from this study, nurses could be consulted for more practical PPE designs to facilitate their movements and establishing a connection with their patients.

Nurse leaders could use these findings to increase the awareness of the danger that nurses may encounter during such crises and request "a danger pay allowance" to provide them with additional compensation during exceptional times.

Study limitation

This study focuses on Arab nurses from collectivist communities. Other nurses with different ethnicities may have different experiences with providing care to patients with COVID-19. Furthermore, the study used the telephone approach interview, although this approach has a wide range of advantages such as but not limited to overcoming the geographic limitations, it could have limited cultivating the rapport and connection between the interviewer and the interviewee because of the absence of visual or non-verbal cues which in turn could have affected the richness of the interviews.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Isra University Ethics Committee (no. JS/BA/94). The patients/participants provided their written informed consent to participate in this study.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Factors influencing hospital anxiety and depression among emergency department nurses during the COVID-19 pandemic: A multi-center cross-sectional study

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Introduction: The emergency department (ED) is a highly stressful environment, which exposes nurses to infection. ED nurses handle life-threatening conditions, endure long working hours, and deal with anxious patients and their families.

Aim: This study aimed to examine factors, which may influence anxiety and depression levels among ED nurses during the coronavirus disease 2019 (COVID-19) pandemic.

Methods: A cross-sectional design was used with 251 participants from six hospitals in Saudi Arabia (mean age = 32.7 ± 6.59, range = 21–54 years, 70.5% females). Data were collected using the Hospital Anxiety and Depression Scale (HADS), and the analysis was conducted using structural equation modeling (SEM).

Results: Based on the HADS scores, 29.1 and 25.5% of ED nurses were identified as doubtful cases for depression and anxiety, respectively. Additionally, 34.7 and 43.3% of ED nurses were identified as definite cases for depression and anxiety, respectively. Higher anxiety levels were observed among female nurses, nurses with lower physical activity levels, and nurses who worked in urban areas. Low physical activity levels and more than 6 years of work experience correlated with a higher level of depression. None of the hypothesized paths in the anxiety and depression models were significant, except for two observed variables—namely, work location and physical exercise in the anxiety model and physical exercise in the depression model.

Conclusion: Emergency department nurses expressed high levels of anxiety and depression during the COVID-19 pandemic, which may negatively affect their performance and reduce care quality. Therefore, health care leaders should implement specialized mental health education programs focused on nursing occupational safety and support to improve ED nurses' psychological well-being. Specific attention should be paid to ED female nurses who work in urban areas, especially those with more than 6 years of experience.

KEYWORDS

mental health, female nurses, urban area, healthcare, psychology, COVID-19

Introduction

The emergency department (ED) is a highly stressful environment, which exposes nurses to infection. ED nurses handle life-threatening conditions, endure long working hours, and deal with anxious patients or their families (1). The spread of coronavirus disease 2019 (COVID-19) and its mutations, such as Omicron, have contributed to increased stress in the ED environment (2, 3). This is because emergency care is the front treatment line for COVID-19 patients. Therefore, ED nurses are more vulnerable to psychological distress, particularly anxiety and depression (2).

Anxiety is a mental health condition characterized by excessive worrying and at least three of the following symptoms: restlessness, fatigue, irritability, difficulty concentrating, muscle tension, or sleep disturbance (3). Depression is a disorder associated with a low mood that impacts an individual's day-to-day functioning (3). Depression and anxiety symptoms experienced during the pandemic may be associated with individuals' perception of COVID-19 as a collective traumatic event (4, 5). Both of these conditions are key determinants of psychological distress. They are associated with sleep disturbance, poor coping behaviors such as disordered eating and addictive behaviors, and poor quality of life (6–8).

Before the COVID-19 pandemic, Saudi Arabia and other countries in the region had already experienced outbreaks that negatively impacted the public and healthcare providers. For example, the outbreak of Middle East Respiratory Syndrome Coronavirus (MERS-CoV) was identified in 2012. According to the European Centre for Disease Prevention and Control, 887 reported MERS-CoV cases in 2014, approximately 85% of which were reported in Saudi Arabia (8). Of 386 healthcare providers in Saudi Arabia, where approximately 76% were nurses, a study reported high anxiety levels during this period, and fears of contracting MERS-CoV were high, specifically for professionals working in high-contact areas with suspected or positive virus cases (9). In March 2020, Saudi Arabia declared a national emergency due to the emergence of the COVID-19 pandemic (10), and subsequently, COVID-19's psychological impact intensified among health care providers. The prevalence of depression, anxiety, and stress among Saudi Arabian healthcare professionals are still high (11). A study conducted in Qatar, during the COVID-19 pandemic, found that 10.6% of healthcare workers tested positive for the virus, and nurses and midwives had the highest infection rates accounting for 33.2% of all the infected healthcare workers (12).

Since the beginning of the COVID-19 outbreak, numerous studies have measured the prevalence of factors contributing to anxiety and depression among healthcare providers. A meta-analysis of 65 studies exploring COVID-19's psychological impact on healthcare workers reports an anxiety prevalence of 31–38%. This prevalence was higher among nurses than doctors (39.3 vs. 32.5%) (13). Moreover, depression prevalence ranged from 28 to 35%. This prevalence was higher among nurses than doctors (42.4 vs. 39.1%) (13). These high incidences of anxiety and depression are attributed to a variety of factors and characteristics, such as age (14), physical activity (15), work location (16), and years of experience in the medical profession (15, 17, 18). Studies have reported inconsistent figures for the prevalence of anxiety and depression symptoms among nurses. For instance, a cross-sectional national study in China reported that the depression rate was 44% among ED nurses (19). Another recent study during the COVID-19 pandemic found that over half of healthcare providers had anxiety and depression, with nurses reporting higher levels of anxiety and depression than other healthcare providers (20). Conversely, a study in China found lower depression (29%) and anxiety (21%) rates among nurses during the COVID-19 pandemic (21).

The poor psychological health of healthcare providers negatively impacts their personal and professional well-being. At an individual level, poor psychological health could lead to suicide, substance abuse, and physical illnesses such as cardiovascular, musculoskeletal, and metabolic diseases (8, 11, 12). At a professional level, poor psychological health is associated with reduced clinical competency, proneness to clinical errors, communication breakdown, absenteeism,

poor job performance, and increased turnover (22). These undesirable consequences of poor psychological health ultimately affect the quality of patient care and safety (22).

Early recognition of psychological health issues among healthcare providers, particularly ED nurses, is essential for improving the quality of patient care and safety. Estimating the prevalence of depression and anxiety among ED nurses is critical for assisting the health authorities in identifying factors contributing to nurses' distress and implementing mitigation strategies. To our knowledge, there is no data on the prevalence of anxiety and depression among ED nurses in Saudi Arabia during the COVID-19 pandemic. This study aimed to examine the prevalence and influencing factors of hospital anxiety and depression among ED nurses during the COVID-19 pandemic in Saudi Arabia. According to existing literature, several factors could influence hospital anxiety and depression (14–18). Therefore, in this study, we hypothesized that factors including age, sex, marital status, years of experience, work location, shift duration, and physical exercise would influence hospital anxiety and depression levels among ED nurses. We further hypothesized that ED nurses would exhibit high hospital anxiety and depression levels.

Materials and methods

Study design

A cross-sectional design was used to examine the factors, which may influence anxiety and depression levels among ED nurses during the COVID-19 pandemic in Saudi Arabia.

Setting

This study was conducted in two main Saudi Arabian provinces—Medina and Riyadh. Four hospitals in Medina Province were surveyed, with one located outside the city in a non-urban area. Two hospitals in Riyadh Province were surveyed, with one also located outside the city in a non-urban area. Hospitals were chosen based on the level of medical care provided to ensure the inclusion of at least one tertiary and secondary hospital from each province. Moreover, EDs in these hospitals predominantly admitted COVID-19 patients. The data were collected between September and December 2021.

Sample

G*Power was used to determine a sufficient sample size (23) using an alpha of 0.05, a power of 0.80, and a small effect size (f = 0.10). The researchers used a small effect size to detect significant results. Based on the aforementioned parameters and small effect size, the desired sample size was 235 participants. An online self-report questionnaire was developed through Google Forms, and the link was sent to head nurses and charge nurses, who distributed the questionnaire among ED nurses. The targeted hospitals had 362 registered ED nurses (**Figure 1**). In total, 251 questionnaires were completed and submitted, with an overall response rate of 70%. All participants were adults over 18 years old working in EDs as nurses.

Measurements

Data were collected electronically using an English self-reported questionnaire. The questionnaire comprised two parts. The first part collected demographic data: age, sex, marital status, location of the working hospital, years of experience, physical exercise, and weekly work shifts. The second part included the Hospital Anxiety and Depression Scale (HADS), which is widely used in clinical settings (24). HADS is a 14-item scale with two subscales—seven items to measure anxiety and seven to measure depression. Depression items tend to focus on the anhedonic symptoms of depression, whereas anxiety items tend to focus on generalized anxiety symptoms (25). Each item is scored on a 4-point Likert scale ranging from 0–3. The total scores for both the anxiety and depression subscales range from 0 to 21. A score of 7 or less on the subscales indicates normal anxiety and depression levels, 8–10 indicates doubtful cases of anxiety and depression, and 11–21 indicates a definite case of anxiety and depression (26). Internal reliability coefficients reported in the literature for the scale are quite robust, with a Cronbach's alpha of 0.83 and 0.82 for the anxiety and depression subscales, respectively (21). In our sample, the HADS exhibited adequate internal consistency with a Cronbach's alpha of 0.79 and 0.78 for the anxiety and depression subscales, respectively.

Ethical considerations

Approval for conducting the study was obtained from the Institutional Review Board of the Ministry of Health in Saudi Arabia (150-2021). The researchers did not collect any identifying or personal information from the participants to maintain the latter's privacy and confidentiality. The primary researcher stored data on a personal computer. Participation in this study was voluntary. Additionally, all participants were made aware of the study's aims and informed about their right to withdraw at any time.

Statistical analysis

Statistical Package for the Social Sciences (SPSS) software version 28 and AMOS version 26 were used to analyze the

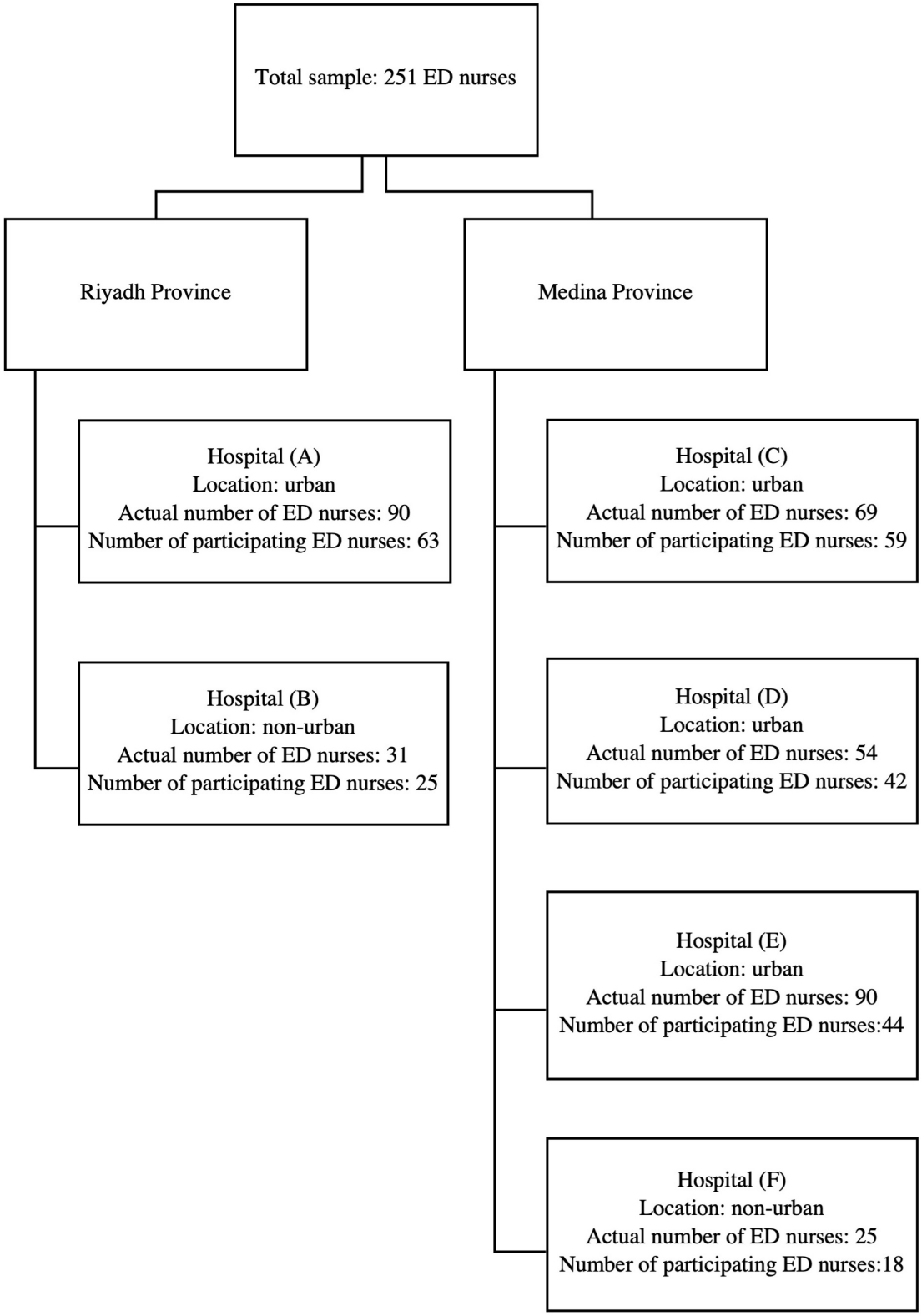

FIGURE 1
Number of ED nurses approached versus the number of ED nurses who participated.

data. Descriptive statistics, including mean, standard deviation, median, IQR, frequency, and percentage, were used to describe the characteristics of the study sample. Additionally, due to the violation of the normality assumption, non-parametric tests (Mann–Whitney U test and Spearman's rank correlation) were conducted to compare depression and anxiety scores across participants' factors and examine the relationships among the study variables. Structural equation modeling (SEM) was used to explore the association between these factors. Overall model fit was assessed using the comparative fit index (CFI), standardized root mean square residual (SRMR), and Tucker-Lewis index (TLI). An SRMR <0.08, CFI, and TLI equal to or above 0.95 indicated an adequate model fit (5, 7). We tested the association between anxiety and depression with age, sex, marital status, years of experience, hospital locations, work shifts, and physical exercise factors. A p-value of $\leq$0.05 was considered statistically significant.

Results

Demographic characteristics

A total of 251 ED nurses participated in the study. The mean age of the participants was 32.7 years (range = 21–54 years). Most respondents were females (70.5%), married (50.6%), had over 10 years of nursing experience (35.5%), worked an 8-h dayshift (41%), and performed regular physical exercise (57.8%) (Table 1).

Prevalence of anxiety and depression among emergency department nurses and their association with participants' characteristics

The anxiety score median (Q1–Q3) was 10.0 (7.0–13.0), while the depression score median (Q1–Q3) was 9.0 (6.0–12.0). These scores were divided into three categories: normal scores, doubtful cases, and definite cases. Approximately one-third of ED nurses (36.3%) exhibited normal scores on the depression scale, followed by definite depression cases (34.7%), and finally, doubtful depression cases (29.1%). Simultaneously, most ED nurses (43.4%) were definite cases on the anxiety scale, followed by normal scores (31.1%) and then doubtful cases (25.5%) (Table 2).

Mann–Whitney U test revealed that anxiety scores were significantly higher among female nurses working in ED than male nurses (U = 532, z = −2.34, p = 0.019, with a low effect size r = 0.18). ED nurses who performed regular physical exercise reported lower depression and anxiety scores. This difference was significant for both depression (U = 595, z = −3.05, p = 0.024, with a low effect size r = 179.19) and anxiety scores (U = 640, z = −2.25, p = 0.002, with a low effect size r = 0.14). Anxiety scores were significantly higher among ED nurses working in urban areas than those working in non-urban areas (U = 195, z = −2.76, p = 0.006, with a low effect size r = 0.17). Furthermore, nurses with more than 6 years of experience reported higher depression and anxiety scores than nurses with less than 6 years of experience. However, a statistically significant difference was observed in the depression scores (U = 660, z = −2.11, p = 0.035, with a low effect size r = 0.13) (Table 3).

The association between participants' characteristics and hospital depression and anxiety

Table 4 shows a strong correlation between anxiety and depression (r = 0.674, p = 0.001). Physical activity, work location, age, and sex were weakly correlated with anxiety. Years of experience and physical activity were weakly correlated with depression. Therefore, non-significant variables and paths were

TABLE 1 Demographic characteristics (N = 251).

Measure	N	M	SD
Age (years)	251	32.7	6.59
Measure	***N***	**%**	
Gender			
Male	74	29.5	
Female	177	70.5	
Marital status			
Single	100	39.8	
Married	127	50.6	
Divorced	24	9.6	
Years of experience			
1–3 years	62	24.7	
4–6 years	52	20.7	
7–9 years	48	19.1	
10 years and more	89	35.5	
Work shift per week			
8 h day shift	103	41.0	
8 h evening shift	26	10.4	
8 h night shift	30	12.0	
12 h day shift	48	19.1	
12 h night shift	44	17.5	
Work location			
Urban	224	89.2	
Non-urban	27	10.8	
Do you perform regular physical exercise?			
Yes	145	57.8	
No	106	42.2	

N, number of participants; M, mean; SD, standard deviation; %, percentage.

not included in the path analysis model, which was used to predict anxiety and depression (Figure 2). This model had an excellent fit for all measures [$\chi^2(1) = 0.126$, $p = 0.722$, CFI = 1.00, TLI = 1.05, RMSEA = 0.00, SRMR = 0.008], and accounted for 91.5 and 33.0% of the variance in anxiety and depression, respectively. Figure 2 shows that physical exercise negatively predicted depression, whereas anxiety and sex exhibited a significant direct effect on depression. Similarly, depression,

TABLE 2 Descriptive anxiety and depression statistics among ED nurses (*N* = 251).

Variables	Total score (*N* = 251)	0–7 Normal cases		8–10 Doubtful cases		11–21 Definite cases	
	MD (Q1–Q3)	*N*	%	*N*	%	*N*	%
Prevalence of depression among ED nurses	9.00 (6.00–12.0)	91	36.3	73	29.1	87	34.7
Prevalence of anxiety among ED nurses	10.0 (7.00–13.0)	78	31.1	64	25.5	109	43.4

N, number of participants; MD, median; Q1, first quartile; Q3, third quartile.

TABLE 3 Differences in factors contributing to anxiety and depression among ED nurses (*N* = 251).

Variables	*N*	Depression		Anxiety	
		MD (Q1–Q3)	*p*	MD (Q1–Q3)	*p*
Sex			0.869		0.019*
Female	177	9.0 (6.0–11.0)		10.0 (7.0–13.0)	
Male	74	9.0 (5.0–12.0)		9.0 (5.0–12.0)	
Physical activity			0.024**		0.002**
Yes	145	9.0 (6.0–13.0)		9.0 (7.0–14.0)	
No	106	10.0 (5.0–11.0)		10.0 (6.0–12.0)	
Work location			0.179		0.006**
Urban	224	9.0 (6.0–11.7)		10.0 (7.0–13.0)	
Non-urban	26	8.50 (1.0–12.0)		6.00 (1.0–11.2)	
Years of experience			0.035*		0.829
≤6 years	114	9.0 (5.0–11.0)		10.0 (7.0–13.0)	
>6 years	137	10.0 (6.0–12.0)		10.0 (6.0–12.0)	
Work shift duration			0.854		0.367
8 h shift	159	9.00 (6.0–11.0)		10.0 (7.0–12.0)	
12 h shift	92	9.00 (5.0–12.0)		10.0 (6.0–14.00)	
Work shift time			0.759		0.456
Day shift	177	9.00 (5.50–11.0)		10.0 (6.0–13.0)	
Night shift	74	9.00 (5.75–12.0)		10.0 (7.0–13.0)	

*p < 0.05; **p < 0.01. N, number of participants; MD, median; Q1, first quartile; Q3, third quartile.

TABLE 4 Correlations among anxiety, depression, and participants factors.

Measure	1	2	3	4	5	6	7	8	9
1. Anxiety	–								
2. Depression	0.674**	–							
3. Age	−0.178**	0.062	–						
4. Sex	0.148*	0.010	0.122	–					
5. Marital status	0.037	0.111	0.501**	0.085	–				
6. Work location	−0.175**	−0.085	0.043	−0.267**	−0.029	–			
7. Years of experience	0.038	0.149*	0.729**	0.174**	0.541**	−0.018	–		
8. Physical activity	−0.143*	−0.193**	−0.240**	0.040	0.231**	0.055	0.224**	–	
9. Work shift	0.047	0.019	−0.126*	0.054	−0.050	−0.135*	−0.038	−0.040	–

The symbols * and ** indicate that correlation is significant at the levels of 0.05 and 0.01, respectively.

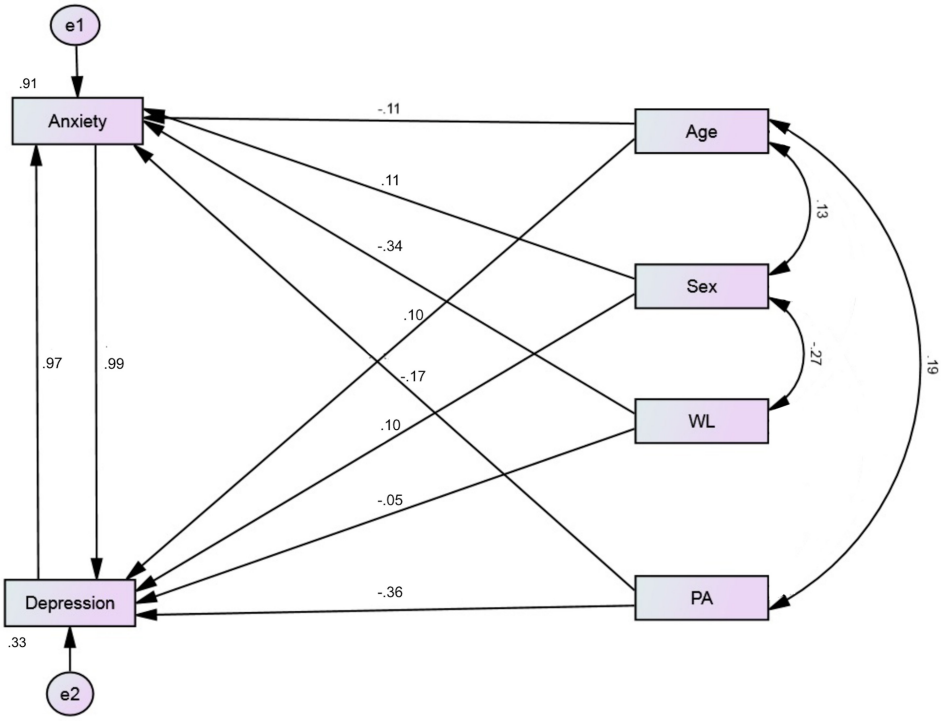

FIGURE 2
Structural equation path model predicting anxiety and depression in ED nurses.

physical activity, work location, age, and sex exhibited a significant direct effect on anxiety.

Physical exercise exhibited a weak indirect effect on depression *via* anxiety (β = −0.161, 95% CI: −3.113 to −0.021, p = 0.025). The indirect effects of sex and work location on depression were marginal (p = 0.059 and 0.063, respectively). Physical exercise and work location exhibited significant indirect effects *via* depression on anxiety (β = −0.197, 95% CI: −3.113 to −0.021, p = 0.004) and (β = 0.202, 95% CI: −0.006 to 2.634, p = 0.011), respectively. The indirect effect of age on anxiety was marginal (p = 0.064).

Discussion

This study examined the prevalence of depression and anxiety among ED nurses in Saudi Arabia during the COVID-19 pandemic. The effects of ED nurses' characteristics on depression and anxiety were also analyzed. Combining respondents in the categories of doubtful and definite cases, approximately 64 and 69% of ED nurses can be reported as cases of anxiety and depression, respectively. These results are similar to a study conducted in China, where researchers found that less than half of 1,103 ED nurses were depressed (19). Anxiety and depression were also high among 441 nurses in Iran (16). In a study conducted in Saudi Arabia during the COVID-19 pandemic, just over half of the 502 healthcare providers reported depressive and generalized anxiety disorders. Nurses exhibited significantly higher depressive and generalized anxiety disorder scores than other healthcare providers (18). Another Saudi Arabian study revealed moderate to high perceived stress among 176 frontline nurses, with high perceived infectability and germ aversion during the COVID-19 pandemic (27). ED nurses often deal with more severe and life-threatening cases that need close-contact interpersonal interactions with infectious patients (28). Moreover, factors such as a heavy workload, adverse events, and erratic working hours contribute to increased depression and anxiety among these nurses (29, 30). Consequently, with the escalation of urgent cases during the COVID-19 pandemic imposing undue strain on an already stressful environment, nurses are likely to experience increased stress and anxiety levels.

In the current study, specific characteristics were associated with the high prevalence of depression and anxiety among ED nurses. Age was a significant negative predictor of anxiety, consistent with several studies that reported higher anxiety levels among young adults during the COVID-19 pandemic (31). Age was negatively correlated with physical activity and positively correlated with marital status and years of experience. We found that regular exercise can significantly reduce the levels of depression and anxiety among ED nurses. This result

was expected because regular physical activity tends to reduce the risk of depressive illnesses (32, 33). A study conducted among healthcare workers in Saudi Arabia during the COVID-19 pandemic revealed that inadequate exercise significantly predicted negative mental well-being and low self-efficacy (15).

In the current study, work location only significantly affected ED nurses' anxiety levels. Nurses who worked in urban areas reported significantly higher anxiety levels than those who worked in non-urban areas. Our results are inconsistent with a study conducted in Iran during the COVID-19 pandemic; wherein there were no significant differences in depression and anxiety between urban and rural areas (16). A possible explanation for this is the large number of patients in our study who visited EDs at hospitals in urban areas, likely owing to the high population density in these areas. These numbers have substantially increased during the COVID-19 pandemic, thus increasing the workload of ED nurses. As mentioned above, the workload is a significant risk factor for negative psychological impacts on ED nurses (29, 30).

The present study's results further indicated that female nurses were more depressed and anxious than male nurses; however, a statistically significant difference was only observed in anxiety scores. Our results agree with reports from China and Iran during the COVID-19 pandemic, where researchers found that female nurses had significantly higher depression and anxiety scores (16, 21). Our results also align with a study among healthcare providers in Saudi Arabia, which found that female healthcare workers were significantly more depressed and anxious during the COVID-19 pandemic (20). However, our results are inconsistent with a similar study, which found that perceived stress among nurses did not differ by gender during the pandemic (27). In general, women frequently report higher anxiety levels than men (34). This may be due to the prevalence of female nurses with families, whose responsibilities often extend to caring for family members, children, and others. Hence, their fear of contagion may increase while having to attend to ED patients during a pandemic (35).

In the current study, ED nurses with more than 6 years of experience were more depressed and anxious than those with six or fewer years of experience. However, only depression was significantly different between the groups. Our result is inconsistent with studies from Pakistan (17) and Vietnam (18), which showed that nurses with less experience exhibited higher depression and anxiety levels. A study conducted in Saudi Arabia found that healthcare workers with less experience reported negative mental well-being and low self-efficacy (15). The present study's results were unexpected as most studies indicate that younger nurses experience more negative psychological outcomes than their older counterparts (36–39). However, the COVID-19 pandemic is an anomalous situation and, thus, a possible explanation for the variant results. The pandemic may exacerbate experiences of depression and anxiety among all nurses despite their experience level.

Finally, stress levels were higher among nurses during the COVID-19 pandemic, correlating with higher depression and anxiety levels (40). In the current study, 64 and 69% of ED nurses were classified as doubtful/definite cases of anxiety and depression, respectively. These levels are considered relatively high. A study conducted in Saudi Arabia on 999 international nurses before COVID-19 found slightly lower scores for anxiety and depression compared with our results, where 54% of nurses were depressed and 65% were anxious (41). Another study comprising 102 Australian nurses before the COVID-19 pandemic showed even lower scores, with 32.4 and 41.2% of nurses being depressed and anxious, respectively (42). The prevalence of anxiety and depression among 850 nurses in a Hong Kong study was also low (37.3 and 35.8%, respectively) (43). Therefore, we concluded that ED nurses experienced substantially higher levels of anxiety and depression during the COVID-19 pandemic.

Limitations

This study has some noteworthy limitations. The first is using a cross-sectional design, which only provides a snapshot of the participants at a given time. The second is using a convenience sampling method with a small sample size, which could result in respondent bias due to the group's heterogeneity, such as in the age and gender of participants. This could reduce the results' generalizability. The third limitation is using an English version of the measurement with nurses from different backgrounds. Although all the nurses understood the language, this could have affected the accuracy of anxiety and depression measurements, as English is not their first language. Lastly, our results support the protective role of physical exercise. However, details on the type, frequency, and duration of physical activity performed were not assessed. This point should be addressed in future studies in order to maximize the use of exercise as a distress-mitigating intervention among ED nurses.

Conclusion

The results of this study demonstrate a moderate-to-high prevalence of anxiety and depression among ED nurses in Saudi Arabia during the COVID-19 pandemic, with certain demographic characteristics associated with this high prevalence. Higher anxiety levels were associated with being female, low levels of physical activity, and working in an urban area. Similarly, low levels of physical activity and having more than 6 years of experience were correlated with a high

level of depression. In conclusion, ED nurses in Saudi Arabia might suffer from psychological distress, particularly anxiety and depression, which could impact their performance and reduce the quality of care. Therefore, healthcare leaders in Saudi Arabia should implement specialized mental health education programs focused on nursing occupational safety and support. These programs can help improve ED nurses' psychological well-being. Specific attention should be paid to ED female nurses who work in urban areas, especially those with more than 6 years of experience. ED nurses must be involved in stress management and coping strategy programs to maintain psychological well-being and reduce psychiatric comorbidities.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Saudi Ministry of Health Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

Author contributions

NA: conceptualization, methodology, formal analysis, and writing—original draft, review and editing. AA and FA: formal analysis, writing—original draft, review and editing. SA and HA: data curation, and writing—review and editing. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Impact of the self-directed learning approach and attitude on online learning ineffectiveness: The mediating roles of internet cognitive fatigue and flow state

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Online learning has become an important learning approach in universities. However, since many students may have been exposed to online learning for the first time during this period of the COVID-19 pandemic, the quality factors of online learning and psychological distress of students need to be considered in the research on their learning. This paper discusses factors that influence the learning effect of university students in the online learning environment. A total of 377 university students participated in the survey. Structural equation modeling was used to verify the research hypotheses. The results show that the self-directed learning (SDL) approach and attitude can negatively predict students' Internet cognitive fatigue (ICF) and positively predict their Flow, whereas perceived learning ineffectiveness can be predicted by Internet cognitive fatigue positively and by Flow state negatively. The results can be a reference for online teachers to enhance students' online SDL attitude, and to discipline their SDL approach so as to promote online learning effectiveness.

KEYWORDS

online learning, self-directed learning approach, self-directed learning attitude, internet cognitive fatigue, flow, learning ineffectiveness

Introduction

Online learning has been widely adopted since 2020 (1). In order to achieve better online learning effectiveness, the realization and maintenance of online learning quality must be addressed (2). Moreover, psychological distress, such as attention and self-directed learning, has a great influence on online learning (3). Self-directed learning (SDL) involves the whole learning process from diagnosing learning needs, describing learning objectives, to evaluating learning outcomes by the learners themselves (4). Kim et al. (5) suggested that designing effective learner content to promote students' interaction is the most important work in maintaining their motivation for online learning (5). In these courses the quality of learner-content interaction may not be a predominant factor; rather, individual self-directed learning is more important (6). Thus,

to explore the learning effectiveness of online learning, this study investigated learners' self-directed learning related to their achievement of the desired learning outcomes.

As Cinquin et al. (7) pointed out, it cannot be expected that all students will find online tools beneficial, as students differ in their learning preferences and styles (7). In particular, some online courses may result in impairments of cognitive function (attention, memory, etc.). On the other hand, when navigating online learning environments, some learners may experience a state of flow (8). While in a flow state, learners concentrate on the activity being performed and lose awareness of other environmental stimuli unrelated to their learning (9). Some studies have indicated that students who experience Internet cognitive fatigue may not enjoy online learning (10). Flow experience has been found to effectively enhance online learning, for example, learning English as a second language (11). However, few studies have discussed how these two mental states interact during online learning. Thus, the present study also explored learners' Internet cognitive fatigue and flow state while they were involved in the online learning process.

Learning outcome is one of the measurements to assess how effective a learning platform is. The perception of the learning effectiveness of online learning is dependent upon whether the desired outcomes are achieved (12). The "dark" aspect of psychology indicates that young people are inclined to view bias in the social world through the external manifestations of lower grades (13). For example, adolescent students tend to make negative evaluations of social norms (14). Thus, in this study, learning performance was replaced by learning ineffectiveness so as to better enable participants to make self-evaluations of their own learning performance perceptions (15). Moreover, learning effectiveness perceived in different contexts is important to understand, as different learning interventions might influence the effectiveness differently. Thus, this study established a structural equation model to explore the influence of two aspects of self-directed learning (approach and attitude) on the different performance of attention (cognitive fatigue and flow state), and the role of these four factors on the effect of online learning performance. According to the research results, people can train learners' self-directed learning approach and give targeted guidance to their self-directed learning attitudes, so as to promote concentration and avoid cognitive fatigue, effectively improving the online learning performance in the future.

Theoretical background

Self-directed learning approach and attitude

Tough (16) first proposed the concept of "self-directed learning" (SDL) as a way of learning (16). Knowles (4) defined it as an approach whereby learners diagnose their own learning needs, clearly describe their learning objectives, look for learning resources, choose and implement suitable learning strategies, and evaluate their learning outcomes, all without others' help (4). Caffarella (17) described SDL as an attitude toward autonomous learning (17). Taken together, SDL comprises two orientations: attitude orientation and approach orientation. In attitude orientation, SDL is considered to be a personal trait of the learner. As well as having different attitude orientations, learners also have different degrees of autonomy. In the approach orientation, the emphasis is placed on learners' learning activities such as their planning and implementation of learning strategies in and after class (18). Moreover, attitudes and actions (approaches) can generate context-related learning effectiveness (19). University students' SDL when taking online courses, including the self-directed learning approach and self-directed learning attitudes, was introduced into this study.

The trait activation theory (TAT) explicates how work situations comprising shared challenge and hindrance stressors can be relevant for the expression of online learning (20). TAT highlights important interactions between person and situation variables. In this context, self-directed learning in online learning was proposed. Song and Hill (21) began to focus on self-directed learning in an online learning environment, and built a SDL model in an online context that combined SDL with personal attributes and learning processes, indicating the impact of environmental factors on SDL (21). Kim et al. (22) took a closer look at the application of self-directed learning in the field of online learning (22). They found that SDL could help students who studied online to develop the characteristics of a personalized system, and to improve their ability to manage overall learning activities and monitor their own performance, which could in turn help them to better adapt to online learning. As the expectation of SDL is that individual learners assume responsibility for their own online learning depending on their unique needs and individual goals (23), the roles that the two types of SDL play in online learning have not been extensively discussed. Thus, this study explored university students' two types of SDL, SDL-approach and SDL-attitude, while they learned online.

Internet cognitive fatigue and flow state

The inability to maintain attention is central to the concept and operational definition of cognitive fatigue (24), which has been defined as an executive failure during time spent performing tasks. It involves neglectfulness, loss of memory, distracted attention, as well as a lack of concentration (25). It evokes mind wandering, which may also interfere with other mental processes (26). Cognitive appraisal has been defined as "an evaluative process that determines why and to what extent a particular transaction or series of transactions between the person and the environment is stressful" (27). In this

study, Internet cognitive fatigue (ICF) that is the result of using LINE is referred to as LINE cognitive fatigue (28). ICF may affect students' learning performance, such as by causing distraction and reducing focus, creating a heavy mental load, and causing problems with Internet usage that recurrently influence learning performance (29). In contrast to cognitive fatigue, Csikszentmihalyi (30) introduced the flow state. Flow is defined as a state in which individuals are so deeply engaged in the current activity that they do not pay attention to other activities or the passage of time (30). This state was defined as a holistic experience in which individuals perceive themselves as being totally involved (31). When they are in a flow state, they are absorbed in the activity they are performing, and the focus of their awareness is targeted. Their minds become more unwandered, and they perceive themselves as being able to control their environment (32, 33).

Many of the studies on mental state while using the Internet have used the flow concept to address online navigation phenomena, but they have produced mixed evidence regarding the efficacy of such online learning (34). Thus, this study examined two types of mental state, namely ICF and Flow, in order to clarify some of the reported ambiguities regarding the conceptualization and operationalization of the effectiveness of online learning.

Learning ineffectiveness

In the research on online learning, some studies have focused on the hurdles that impede the effective delivery of online courses; for example, in massive and emergency online platforms (35, 36), factors such as the unpreparedness of most administrators, staff members, and students are hurdles (29). Of particular note is students' desire for learning effectiveness (37). Existing research has shown that young adults try to associate self-perception biases with behavioral outcomes and look down on external attributes (38). Hong et al. (15) used learning ineffectiveness to explore online learning effect (15). Accordingly, the present study considered the role of online learning ineffectiveness related to remote learning.

Literature summary and research significance

Although there has been some research on self-directed learning and attention in academia (24), and on the relationship between them (39), few scholars have explored the significance of self-directed learning by dividing it into learning approach and learning attitude. Some learners have mastered the method of self-directed learning but are not willing to carry it out, while others want to carry it out but do not know how to learn scientifically and effectively. Both of these situations can lead to the failure of self-directed learning, which can be linked with two different forms of attention: cognitive fatigue and concentration. It is also innovative to link these two conditions to two different forms of attention: Internet cognitive fatigue and flow state. It would be interesting to see whether these two different conditions promote concentration or divergence.

In addition, since teenagers tend to have more positive self-perceptions, and what they perceive may not be the same as what they perform, the existing research resulting to promote learning performance may not be suitable (38). Therefore, it is also of great significance to explore whether the conversion of the scale into learning ineffectiveness is different from the positive learning performance results. At the same time, the learning environment of online learning is different from that of traditional learning environments. The situation of online learning changes the self-directed learning and attention of students, which also has an impact on learning effectiveness.

Research model and hypotheses

Hypotheses

While students are navigating online learning environments, they may perceive challenges that link to opportunities for action. When they are in a state of flow, they also engage in and focus on the activity they are performing; they may focus or lose concentration on any environmental change. This is considered desirable insofar as it changes their mental state so that they realize that the challenges they face are in balance with their learning attitude and approaches (40). When students are engaged in online learning, their self-directed learning attitude may affect their ICF and flow states (8). However, few researchers have discussed how the self-directed learning approach and attitude affect the ICF and Flow in the particular context of online learning; thus, the following hypotheses were proposed:

H1 SDL-approach is negatively related to ICF.
H2 SDL-approach is positively related to Flow.
H3 SDL-attitude is negatively related to ICF.
H4 SDL-attitude is positively related to Flow

Online courses have increased the accessibility of learning, but students' ability to concentrate is an important factor in measuring the quality of their online learning (41). Attention guidance can facilitate students' constructive use of instructional materials when they engage in online learning conversations (42). On the other hand, students often carry out online learning in situations where they are easily distracted (43). Many students have reported that they find it difficult to pay attention (44), and previous researchers have aimed to identify when mind wandering occurs. However, few have discussed how students'

ICF and Flow affect their perceptions of learning ineffectiveness in the particular context of online learning; thus the following hypotheses were proposed:

H5 ICF is positively related to students' learning ineffectiveness.

H6 Flow is negatively related to students' learning ineffectiveness in online learning.

Research model

The cognitive appraisal theory (CAT) categorizes personal traits in terms of positive or negative valence, which can trigger different psychological states (45). Moreover, according to the environmental psychology theory (46), it is assumed that the set of physical and tangible cues in an environment affects users' emotional states and behaviors. In the COVID-19 environment of online learning, the self-directed learning approach and attitude serve as mental state antecedents, and learning ineffectiveness is a mental state consequence. As a result, the present study proposed a model to identify individual traits that are subject to environmental factors which shape an individual's vulnerability to COVID-19 as stressor-related online learning problem. Therefore, the research model was conceptualized as shown in Figure 1.

Method

Participants and procedure

A survey with a questionnaire was administered to university students with online learning experience in Jiangsu province, China. The questionnaire was uploaded to an online tool called *Questionnaire Star* (www.wjx.com). A web site, valid for participants to access for one month, was generated and the link was randomly sent to 50 university students in Jiangsu. Participants were then invited to share the link with their classmates. A total of 384 questionnaires were collected. After deleting those questionnaires with unanswered items, the same answer to all items, and less than 2-minute answering time, 377 valid questionnaires remained, giving an effective response rate of 98%.

Instruments

The questionnaire was designed by adapting from previous studies. Two professors majoring in psychology and three in education checked and revised the accuracy of the item statements, using the forward-backward translation approach to obtain the face validity of the questionnaire. A 5-point Likert scale was designed, with 1 for strongly disagree, and 5 for strongly agree. After data collection, the reliability and validity of the questionnaire items and constructs were tested. The questionnaire consists of three parts. The first part is the introduction of the survey and the explanation of the data collected only for the participants with online learning experience. The second part is the investigation of the basic information of the subjects. The third part is the main part of the questionnaire, including the potential variables of SDL-approach, SDL-attitude, Internet cognitive fatigue, and Flow state.

SDL measurement

Self-directed learning can help to understand an individual's attitude toward online learning and provide further insight into how an individual can use learning methods in an online environment (23). This study adopted the scale of Sun (47), which divides self-directed learning into two aspects: approach and attitude. In the original scale, there were five items for self-directed learning approach and five for self-directed learning attitudes (47). The descriptions of these 10 items were adapted according to the circumstances of this study.

SDL-approach measurement

Self-directed learning is the foundation of all learning, whether formal or informal, and the effectiveness of learning is related to individual motivation. All people are capable of self-directed learning, but their development level varies due to individual methods (48). Accordingly, five items were adapted related to how we should achieve self-regulation in learning. Exemplary items include: I can make my own study plan effectively, and When I encounter problems with the use of the online learning system, I will find the best solution by myself.

SDL-attitude measurement

Crook (49) explained that autonomous learners are active and take the initiative in learning, rather than passively waiting to be taught (49). As people take more responsibility for their own lives and benefit from self-discipline in the learning process, self-directed learning attitude refers to whether they have a strong willingness to learn independently. Accordingly, five items were adapted in this study, for example: When a new concept or thing comes along, I like to explore it myself, and When I come across something I don't understand, I like to try to find a solution on my own.

Internet cognitive fatigue measurement

This measure referred to the scale of Schwid (50), where cognitive fatigue is thought to be a cognitive decline on tests

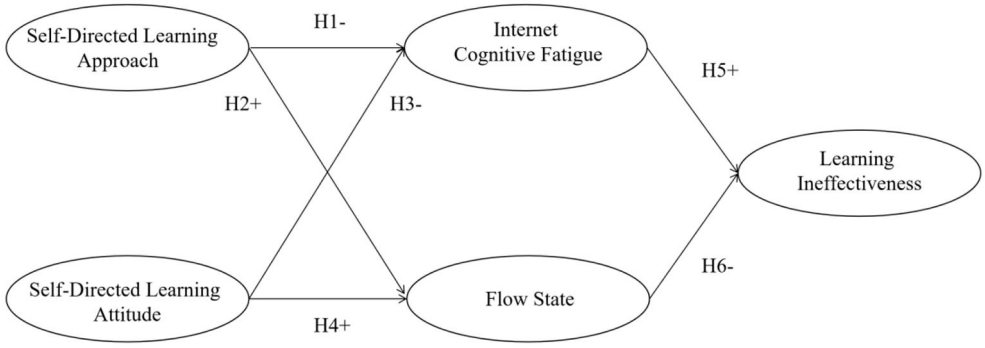

FIGURE 1
Research model.

that require sustained attention. Hong et al. (10) and Hwang et al. (28) mentioned the cognitive decline related to interaction with internet information (10, 28). There were seven items in the original questionnaire pool to explore participants' perceptions of cognitive fatigue. Since the participants of the original questionnaire were those with a steady job, the project description was revised in this study and two questions unsuitable for student participants were deleted. Accordingly, five items were adapted. Examples include: When I study online, I am distracted by the interaction of different avatars, and I cannot quickly grasp what others are saying, and When studying online, if the teacher talks too much at one time, I can't understand.

Flow measurement

When people are in a state of flow, they become absorbed in the activity they are performing, the focus of their awareness becomes narrower, they are less conscious of themselves, and they feel that they have control of their environment (31). Based on the understanding of flow state in existing studies, eight items were self-compiled for this study; examples are: When studying online, I can concentrate on class for a long time, and When I study online, I won't listen and think about other things.

Perceived ineffectiveness of online learning measurement

Online learning ineffectiveness was introduced by Hong et al. (15). Considering the "dark" psychology of young adults, Hong et al. (15) used ineffectiveness rather than effectiveness when designing items for students' online learning performance (15). There were nine items in the original questionnaire, but one item with low reliability was deleted in this study. Accordingly, eight items were adapted; examples are: Since learning online, the quality of my homework has deteriorated, and Since online study began, my ability to observe and find problems has become weaker.

Results

First-order CFA was first applied to determine the reliability of the tool and to delete unreasonable questionnaire items. The reliability and validity of variables were tested to determine the credibility of the research instrument. Finally, structural equation modeling (SEM) was used to verify the hypothetical structural model. In this study, SPSS 24.0 was used for descriptive statistics and reliability and validity analysis, and AMOS 24.0 was used for CFA and path analysis of the structural model.

Participant information

Of the respondents, 29.2% were males and 70.8% were females, 40.3% were freshmen, 38.7% were sophomores, and 21.0% were juniors (no seniors were recruited because most university senior students were in internships and were not participating in school courses at the time). As for their online learning time, about 13.5% spent 1–2 h per week, 51.2% spent 2–4 h per week, 24.4% spent 4–6 h, and only 10.9% students had more than 6 h per week of online learning. Regarding the number of online courses, 17.0% had 1–3 courses, 76.7% had 4–6, 5.6% had 7–9, and only 0.8% had more than 10 online courses.

Item analysis

The original questionnaire had 31 items in total, including SDL-approach, SDL-attitude, ICF, Flow, and learning ineffectiveness. When a sample is used in first-order

TABLE 1 Dimension reliability and validity analysis.

Variable	Measure item	M	SD	FL	CR	AVE	Cronbach's Alpha
Self-directed learning approach	SDL-approach 1	3.45	0.791	0.774	0.8176	0.5991	0.819
	SDL-approach 2	3.62	0.752	0.770			
	SDL-approach 3	3.62	0.807	0.778			
Self-directed learning attitude	SDL-attitude 1	3.69	0.875	0.787	0.8888	0.6669	0.889
	SDL-attitude 2	3.86	0.911	0.781			
	SDL-attitude 3	3.64	0.839	0.852			
	SDL-attitude 5	3.69	0.822	0.844			
Internet Cognitive Fatigue	ICF1	2.67	0.983	0.858	0.8871	0.6628	0.893
	ICF2	2.40	0.873	0.800			
	ICF3	2.32	0.841	0.796			
	ICF5	2.80	1.056	0.801			
Flow	Flow 4	3.90	0.769	0.793	0.8871	0.6629	0.897
	Flow 5	3.98	0.711	0.795			
	Flow 6	3.89	0.733	0.857			
	Flow 7	4.03	0.710	0.810			
Learning ineffectiveness	LI1	2.62	1.043	0.729	0.9495	0.7593	0.950
	LI2	2.57	1.047	0.887			
	LI3	2.56	1.080	0.942			
	LI4	2.54	1.118	0.896			
	LI5	2.54	1.108	0.922			
	LI6	2.62	1.066	0.835			

M, Mean; SD, Standard Deviation; FL, Factor Loading; CR, Composite Reliability; AVE, Average Variance Extracted.

confirmatory factor analysis (CFA), if the factor loading is less than 0.5, the items should be deleted (51). Moreover, the highest residual values of items in each construct should be deleted until the threshold value met the first-order CFA requirements (51). The value of GFI was 0.919; NFI was 0.943; CFI was 0.972; RMSEA was 0.049; and χ^2/df was 1.907. Accordingly, the following questionnaire items were retained: self-directed learning approach (3 items), self-directed learning attitude (4 items), ICF (4 items), Flow (4 items) and learning ineffectiveness (6 items), giving a total of 21 items.

Construct reliability and validity analysis

SPSS 24.0 was used to analyze the reliability and validity of the questionnaire. Cronbach's alpha was adopted for the internal consistency analysis. Table 1 shows that the Cronbach's alpha of all constructs was higher than 0.8. The composite reliability (CR) is for measuring the external consistency of constructs. In this study, CR values ranged from 0.82 to 0.95, indicating acceptable validity (51).

According to Fornell and Larcker's (52) study of convergent validity, the higher the convergent validity, the higher the factor loading (FL) (52). According to the previous research, a FL above 0.7 is considered a good value. The AVE (Average Variance Extracted) value should exceed 0.5, indicating that the construct has the effect of convergence. Table 1 shows that all values of FL and AVE are above 0.5, indicating that the questionnaire had a high degree of validity.

When performing construct discriminant validity analysis (as shown in Table 2), we must first obtain the square root of AVE for each dimension, and it should exceed the absolute value of the Pearson correlation coefficient between the two dimensions (53). In the current study, the analysis showed that the square root of AVE value of all variables exceeded the absolute value of the correlation coefficient between variables, thus indicating that the measurement model had good discriminative validity (53).

Hypothesis testing and path analysis

In this study, the absolute fit index and relative fit index were used to evaluate the degree of fit of the model. The value of GFI is 0.906 which is more than 0.9 and < 1.0 (54). NFI and CFI should both be > 0.9 (44). The value of NFI is 0.932 and CFI is 0.961. RMSEA should be < 0.1 (44), and here it is 0.057. From the perspective of the model indexes as Table 3 shows, the χ^2/df,

TABLE 2 Dimension discriminant validity analysis.

Construct	1	2	3	4	5
1. SDL-approach	**0.774**				
2. SDL-attitude	0.388	**0.817**			
3. ICF	0.469	0.422	**0.814**		
4. Flow	0.527	0.435	0.405	**0.814**	
5. Learning ineffectiveness	0.193	0.186	0.307	0.303	**0.871**

The diagonal elements (bold) are the square roots of AVE and the off-diagonal elements are values of the inter-construct correlations.

TABLE 3 Model fitting analysis.

Fitting index	Threshold	Values	Results
Chi-square/*df*	<3	2.234	Supported
RMSEA	<0.08	0.057	Supported
Goodness-of-fit index (GFI)	>0.8	0.906	Supported
Adjusted fitness index (AGFI)	>0.8	0.882	Supported
Normed fitness index (NFI)	>0.9	0.932	Supported
Non-normalized fitness index (NNTI/TFI)	>0.9	0.955	Supported
Comparative fitness index (CFI)	>0.9	0.961	Supported
Incremental fitness index (IFI)	>0.9	0.961	Supported
Relative fitness index (RFI)	>0.9	0.922	Supported

RMSEA, GFI, CFI, NFI, and IFI all fell within the acceptable ranges, illustrating that the model of this study fits the data well.

The hypotheses of the research model were tested by path analysis of the relationship among variables. Table 4 shows that the significance of the five hypotheses proposed in this study was verified. There are significant states among the hypotheses. All of the p-values are < 0.001. The SDL-Approach and SDL-Attitude have a direct negative association with ICF ($\beta = -0.592$, $t = -7.704^{***}$; $\beta = -0.366$, $t = -6.305^{***}$), while the SDL and SDLA have a direct positive association with Flow ($\beta = 0.514$, $t = 8.806^{***}$; $\beta = 0.264$, $t = 6.308^{***}$). Moreover, ICF has a direct positive association with LI ($\beta = 0.202$, $t = 3.728^{***}$), and Flow has a direct negative association with LI ($\beta = -0.273$, $t = -3.732^{***}$).

The determination coefficient R^2 quantifies the variance ratio interpreted by the statistical model. It is an important statistic for summarizing biological benefits. When R^2 values are < 0.6, we consider that 0.3–0.6 is medium, and < 0.3 is low (55). In addition, the model effect size (f^2) was proposed by Cohen (56) to enable researchers to move from simply recognizing statistical significance to providing a more general quantifiable description of the size of the effect (57). f^2 values > 0.8 can be considered large. When f^2 is between 0.2 and 0.8, it can be considered medium, and when it is < 0.2, it can be considered small. In this study, the explanatory power of SDL and SDLA on ICF is 31% ($R^2 = 0.31, f^2 = 0.449$), and Flow is 38% ($R^2 = 0.38, f^2 = 0.613$). The explanatory variance of CF and Flow on LI is 13.0% ($R^2 = 0.13, f^2 = 0.149$). The six variables in this study are therefore shown to have good predictive power (44). However, in order to improve the degree of fit of the model, adjustments to the model were made, as shown in Figure 2.

Discussion

In the existing studies, taking COVID-19 as source of stress, there were many studies on the theoretical literature describing how COVID-19 may affect online learning, for example, similarities and differences between online learning and face-to-face learning (58–60). However, the empirical literature related to the two types of self-directed learning that affect individual mental state and learning effectiveness is limited. Thus, the present study explored the correlates between SDL-approach, SDL-attitude, Internet cognitive fatigue, flow experience, and perceived online learning ineffectiveness. After statistical analysis with item suitability, construct reliability and validity, structural equation modeling was applied to test the hypotheses. The results of this study are discussed as follows.

According to the TAT, individual traits are latent potentials residing in the individual attitude and approach; what triggers mental state is critical for understanding how the two types of SDL affect Internet cognitive fatigue and flow experience in this study. Self-directed learning can be defined as the mode of learning in which students who establish their own study goals and strategies are accountable for outcomes. It is essential to learn by oneself under the threat of COVID-19 (61). According to environmental psychology theory, environmental change may activate or deactivate individual mental activities, and self-directed learning should be prioritized with online learning (61).

Moreover, when students are in a state of flow, they are engaged in and focused on performing the activity, and they may focus or lose concentration as a result of any environmental change (30). ICF may affect students' online learning performance, such as by causing distraction and reduced focus, heavy mental load, and problems with Internet usage that recurrently influence their learning performance (29). Because online learning, which includes either watching video lectures or attending real-time video class meetings, is relatively unrestricted in terms of time and space, individuals can proactively steer the learning environment and accommodate SDL (61). Moreover, as the expectation of SDL is that individuals will assume responsibility for their own online learning depending on their unique needs and individual goals (23), SDL attitude and approach can balance the challenge of online learning and result in a change in mental state (40). How two types of SDL affect two types of mental state in online learning was explored in this study. The results revealed that the SDL approach is negatively

TABLE 4 Path coefficient analysis.

Hypothesis	Causal factors	Standardized coefficient (β)	S.E.	*t*	*p*	Result
H1	SDL-approach→ ICF	−.592	.082077	−7.194704	$p < 0.001$	supported
H2	SDL-approach→ Flow	.514	.058	8.806	$p < 0.001$	supported
H3	SDL-attitude→ ICF	−.366	.058	−6.305	$p < 0.001$	supported
H4	SDL-attitude → Flow	.264	.042	6.308	$p < 0.001$	supported
H5	ICF→ LI	.202	.054	3.728	$p < 0.001$	supported
H6	Flow→ LI	−.273	.073	−3.732	$p < 0.001$	supported

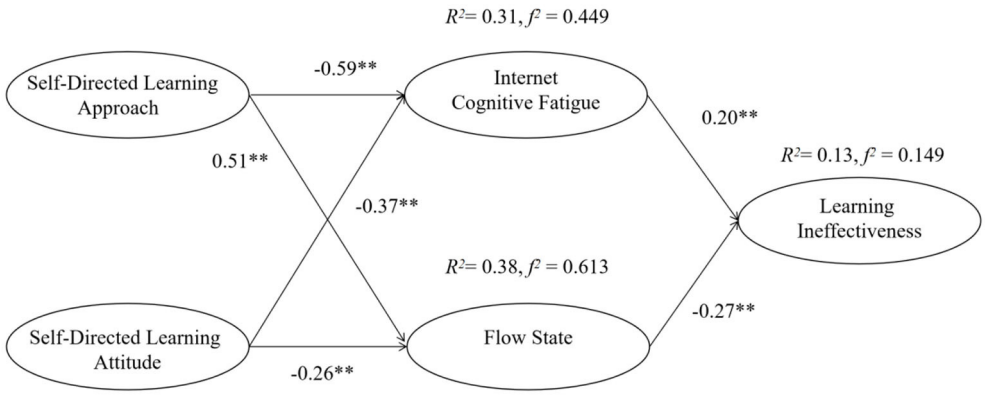

FIGURE 2
The verification of the research model. $^{**}p < 0.01$.

related to ICF but positively related to Flow, whereas SDL attitude is negatively related to ICF but positively related to Flow.

In line with TAT, shared challenge stressors may overwhelm groups to achieve desired work outcomes. On the other hand, taking COVID-19 as a hindrance stressor will inhibit psychometric responses to self-evaluation. Mental states can facilitate or inhibit students' constructive use of instructional materials when they engage in online learning conversations (42, 43). Some studies have reported that paying attention is more difficult when mind wandering occurs (44). However, to explore how students' ICF and Flow affect their perceptions of learning ineffectiveness in the particular context of online learning, the present study found that ICF was positively related to learning ineffectiveness, suggesting that the higher the learner's ICF, the lower their learning performance would be. Thus, H5 is true. Flow is the opposite of ICF, so the higher a learner's level of concentration, the higher their learning performance is; H6 is thus also proved.

Conclusion

According to cognitive appraisal theory, environmental psychology theory, and trait activation theory, this study puts forward that the four factors of self-directed learning approach and self-directed learning attitude, ICF, and Flow will directly or indirectly affect the quality of university students' online learning. Through path analysis for the model, it was found that the self-directed learning approach and self-directed learning attitude can predict two types

of mental state: negatively to ICF and positively to Flow. Moreover, ICF can negatively predict and Flow can positively predict learning ineffectiveness. Therefore, the influence of psychological distress on online learning should be taken seriously.

Implications

The results show that self-directed learning can predict mental state, and has a direct or indirect impact on the ineffectiveness of online learning, confirming that the four factors have a significant influence on learning ineffectiveness. That is similar to the findings of other studies. When conducting online learning for university students, more attention should be paid to the cultivation of students' SDL awareness, carrying out relevant lectures, strengthening the training of their SDL approaches and paying attention to guiding their attitude toward SDL in online learning.

Limitations

There are some limitations of the study that should be noted. First, the snowball sampling method was used to connect with a limited population of university students in one area. Future studies should involve a greater number of participants from a variety of different areas. Second, this study adopts the cross-sectional survey results of a node at a certain time. In the future, more longitudinal data at different time points should be collected, which will increase the objectivity and stability of the conclusions and increase the rigor of the study. Last but not least, the present study focused on cognitive appraisal evaluation under the stress of COVID-19 and explored the correlates between individual trait and mental state of online learning reflected in learning effectiveness, without considering the comparison of types of online learning and online learning effectiveness. Future studies may compare different online approaches to examine participants' cognitive and effective issues.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval were not required for the study on human participants in accordance with the local legislation and institutional requirements. The survey data participants provided were anonymous and would not be of any commercial use.

Author contributions

All authors contributed equally to the conception of the idea, implementing and analyzing the experimental results, writing the manuscript, and reading and approving the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Determining the association between different living arrangements and depressive symptoms among over-65-year-old people: The moderating role of outdoor activities

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Background: China is presently facing the challenge of meeting enormous health demands because of its rapidly aging society. Enrolling older persons in eldercare institutions is a helpful alternative for relieving family caregivers and promoting healthy aging. However, changes in the living environment may negatively affect the mental health of the elderly.

Objective: To explore the association between different living arrangements and depressive symptoms among over-65-year-old people in China and the moderating role of outdoor activities.

Method: The 2018 wave of the Chinese Longitudinal Healthy Longevity Survey (CLHLS) used a mixed sampling method to collect the health and demographic information of 15,874 older adults over 65 years from 23 provinces in China. After considering this study's inclusion and exclusion criteria, the final sample comprised 12,200 participants. The participants' risk of depressive symptoms was assessed using the 10-item Center for Epidemiologic Studies Depression Scale (CESD-10). The potential association between the two elements was tested using a regression model.

Result: This study's findings suggested a significant relationship between depressive symptoms and living arrangements ($P < 0.001$). Participants living alone and those living in eldercare institutions had 1.26-times (95%CI: 1.10–1.44) and 1.39-times (95%CI: 1.09–1.77) higher risks of depressive symptoms, respectively, than those living with household members. Outdoor activities play a moderating role between different living arrangements and depressive symptoms. Among participants who engaged in outdoor activities, no significant difference was observed in the risk of depressive symptoms between those living in eldercare institutions and those living with household members (adjusted odds ratio = 1.15, 95%CI = 0.81–1.64, $P = 0.426$).

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Conclusion: The high risk of depressive symptoms among older Chinese people living alone or in eldercare institutions requires considerable attention. The evidence from this study suggests that older people living alone and those living in eldercare institutions should regularly engage in appropriate outdoor activities.

KEYWORDS

depression, living arrangement, eldercare institutions, aging population, outdoor activities

Introduction

Population aging (and its adverse effects) is becoming a global challenge (1). As in Japan, South Korea, and some European countries, population aging in China has emerged as an increasingly crucial social issue in the last decade. According to the National Bureau of Statistics of China, the number of older people aged over 65 years in China reached 200.56 million (14.2% of the total population) by the end of 2021, indicating that China has become a rapidly aging society (2). The main contributors to this issue are the declining birth rate and the increasing life expectancy (3). The immediate threat of population aging to society is increasing labor and health costs due to chronic age-related conditions. Empirical evidence suggests that age-related diseases, especially among people aged over 65 years, account for over half of the global burden among adults (4). Population aging has also resulted in a social burden in China, potentially contributing to 92.8 million disability-adjusted life-years (DALYs) between 1997 and 2017 (5). Therefore, given that the current population aging trend is almost irreversible, each government's effort focuses on improving health outcomes in the aging population.

Depression is defined as a group of symptoms forming a syndrome and causing functional impairment (6). Depression consists of three main subtypes, including emotional symptoms, neurovegetative symptoms, and neurocognitive symptoms; depressed mood and anhedonia are the fundamental symptoms of depression (6). Depression negatively contribute to the quality of life in aging populations (7). Not only can they considerably reduce each individual's well-being, especially based on the declining physical function in older people, they are also a high-risk factor for many diseases or adverse events (such as suicide, pain, chronic diseases, disability, among others), resulting in more DALYs and years of life lost (YLLs) (8–10). Unfortunately, the prevalence of depressive symptoms among elderly Chinese people was as high as 35.19% (11). Therefore, the research focusing on promoting the mental health of the elderly holds great value at both the social and individual levels.

At present, expanding the industrial scale of eldercare institutions is an essential measure to achieve positive aging and ease the economic burden on society in China (12). Living in eldercare institutions is deemed appropriate behavior because the elderly can benefit from the professional services provided by licensed caregiving staff (13), and family caregivers can be relieved by enrolling older persons in elder care institutions, especially in the era of the post-one-child policy (a family planning measure aimed to control the rapidly growing population). These factors will encourage an increasing population of elderly Chinese individuals to live in eldercare institutions. However, a high prevalence of depressive symptoms was observed among older people living in eldercare institutions (14). Therefore, this study determined the association between depressive symptoms and living arrangements, and explore the moderating role of outdoor activities between depressive symptoms and different living arrangements.

This research framework was designed using the environment-stress theory in environmental psychology (15). This theory states that changes in the living environment (based on how an individual perceives the environment, such as atmosphere, light, and color, among others) will affect an individual's emotional, behavioral, and physiological reactions. Positive emotional reactions in individuals are influenced by elements such as bright light, fresh air, and green spaces in outdoor activities (16–18). Furthermore, individual participation in outdoor activities boosts physical activity and social interaction. Based on the research experience in molecular biology, the serotonin hypothesis is one of the most popular causal hypotheses for depression, suggesting that depression is caused by lower concentrations of the serotonin neurotransmitter (19). Appropriate levels of physical activity can significantly increase the extracellular concentration of serotonin (20). Moreover, the evolutionary theory of loneliness contends that social interaction can effectively lower the increased physical and mental health risks caused by loneliness (21). Therefore, a national-level survey database was selected in this study to examine the differences in the risk of depressive symptoms among the elderly with different living arrangements and whether outdoor activities play a moderating role.

Methods

Study design and sample

This study's data were sourced from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), which was conducted by the National School of Development at Peking University. The nationwide community-based prospective longitudinal study began in 1998, and examinations are conducted every 2–3 years (the latest wave was conducted around 2018). It aims to provide representative data for identifying the determinants of longevity. New participants are registered during the follow-up to reduce the attrition caused by death and loss to follow-up. The CLHLS (2018) was conducted in randomly selected counties and cities in 23 out of 31 provinces in Mainland China (including Beijing, Tianjin, Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, and Shaanxi). It focussed on the health status, quality of life, cognitive function, personality, psychological characteristics, daily activities, disease treatment, and medical expenses of the older Chinese people. The CLHLS was initially designed to facilitate global comparative analysis, and its survey instruments were translated into Chinese from the instruments of the Danish longevity survey (22). The CLHLS used a multistage cluster sampling method to include all consenting centenarians who live in selected areas. Next, other age groups of the same gender (65–80, 80s, and 90s) in the vicinity of the centenarian's place of residence (in the selected street or village, or in the selected city or county) were randomly invited for this study. Well-trained local Center for Disease Control investigators and university students were hired to conduct in-person interviews at the participants' residences. An earlier investigation reported a more detailed introduction to the CLHLS study design (23).

This study's data were sourced from the 2018 wave of the CLHLS. This wave of the CLHLS collected data from 15,874 participants, from October 2017 to July 2019. First, 95 participants younger than 65 years were excluded. Then, 3,403 participants were excluded because of inability or unwillingness to complete the ten-item Center for Epidemiologic Studies Depression Scale (CESD-10) or for answering data with apparent errors. In addition, 73 participants who failed to respond to questions regarding their living arrangements were also excluded. Finally, 12,200 eligible subjects were screened from 15,874 participants. From the data collected from all participants, a total of 12,461 participants completed the CESD-10 scale (a response rate of 78.50%) and 15,549 participants responded to the questions about their recent living arrangements (a response rate of 97.95%), and 15,619 participants reported outdoor activities in the survey (a response rate of 98.39%). The details of the eligible participants are described in the following section. All participants provided written informed consent at the time of participation, and the CLHLS data collection (IRB00001052–13074) was approved by the Biomedical Ethics Review Committee of Peking University.

Measures

Depressive symptoms (dependent variable)

The CESD-10 was used to assess the participants' risk of depressive symptoms and was added to the 2018 wave of the CLHLS questionnaire for the first time. This scale was compiled by Anderson and used after being translated into Chinese (24). The Chinese version of the scale was proven to be well validated for the assessment of depression in the general Chinese elderly population (25). The scale contains eight forward-scoring and two reverse-scoring questions that measure the frequencies of the participant's negative feelings in the past week. A previous report provided specific information for each question (24). Each question has four response options with different frequencies: rarely or none of the time, some or a little of the time, occasionally or a moderate amount of the time, and most or all the time. Forward-scored questions are scored as 0–3 points according to the frequency from low to high, and 3–0 points are scored in the reverse direction. The total range of CESD-10 scores was 0–30, with scores $\geq$ 10 indicating significant depressive symptoms. The Cronbach's α of CES-D-10 was 0.730, indicating a reasonable reliability level of internal consistency. The Pearson correlation analysis revealed that each variable was significantly correlated with the total score of the scale ($P < 0.01$), indicating that the scale has reasonable content validity.

Living arrangements (independent variable)

In this study, living arrangement refers to the recent long-term living status: living with family members (spouse, parents, children, etc.), living alone (without the company of family members for a long time, including babysitters and sexual partners), and living in eldercare institutions (elderly center, elderly home, care home, etc.).

Outdoor activities (moderating variable)

Outdoor activities here refer to individuals leaving their familiar house to participate in positive activities, such as physical activity, social activities, playing chess, fishing, and traveling, among others. The questionnaire in the 2018 wave of the CLHLS included an item about the frequency of regular participation in outdoor activities (including Tai Chi, square dancing, socializing with friends, and other outdoor activities). The older people in China prefer these outdoor activities. There are five different frequencies under the question: There are five different frequencies under the question: (1) almost daily. (2)

at least once weekly. (3) at least once monthly. (4) less than once monthly, and (5) never participate (scoring 4, 3, 2, 1, and 0 points, respectively)Scores < 0 indicate participation in outdoor activities and scores equal to 0 indicate no participation in outdoor activities.

Covariates

The participants' demographic or socioeconomic characteristics (such as gender, age, living location, years of schooling, marital status, income, and hukou status) and health status (number of chronic diseases) were some of the control variables included in this study's analyses. This study included these covariates because they were described as the confounders for depressive symptoms in the previous studies or preliminary univariate analyses.

Age

Age as a risk factor for depressive symptoms in the Chinese elderly was reported in a previous study (26). Age in this study was divided into two groups: 65–80 and over 80 years old.

Hukou status

Hukou is a unique existence in China; it refers to the national household registration that Chinese governments have historically used to try to fix the population in a place geographically. The primary study reported a significant difference in the prevalence of depressive symptoms among residents with different hukou (27). In our study, Hukou was divided into agricultural and non-agricultural.

Marital status

Marital status was categorized as married and living with a spouse, married and living without a spouse, widowed, never married, or divorced. A national-level survey in China found that separation, widow, or divorce are risk factors for depressive symptoms (28).

Years of schooling

Since this database does not collect data on specific educational levels, it only includes each participant's years of schooling. Therefore, the years of schooling were divided into 0 years (illiterate), 1 to 9 years (elementary school or middle school), and over 10 years (high school and above), according to the length of different learning stages. Previous studies found that individuals with higher levels of education have a lower risk of depressive symptoms (28, 29).

Chronic diseases

A total of 13 chronic diseases were included, namely hypertension, dyslipidaemia, diabetes, cancer, hepatitis, heart attack, stroke & cerebrovascular disease, asthma & lung disease, Parkinson's disease, dementia, digestive disease, arthritis, and nephritis. Previous studies have reported a higher risk of depressive symptoms in patients with a higher number of chronic diseases (9).

Household income

Annual household income was classified as < 10,000, 10,000–50,000, 50,000–100,000, and more than 100,000 CNY (1 USD≈6.62 CNY in 2018). A previous study found a negative correlation between income and depressive symptoms in the elderly in China (26).

Disability

The KATZ scale was used to estimate whether participants had difficulty in six activities: eating, dressing, bathing, transferring in and out of bed, using the toilet, and controlling urination and defecation. Respondents were identified as having a disability if they had difficulty completing one of the activities. In all individuals with a disability, difficulty completing 1–2 activities, 3–4 activities, and 5–6 activities were considered mild, moderate, and severe disability, respectively. Our previous study found that individuals with higher levels of disability were at greater risk of depressive symptoms (29). The Cronbach's αvalue was 0.908, indicating a reasonable reliability level.

Data processing and analysis

The original data from the CLHLS database were exported in the SAV. format to Microsoft EXCEL 2016 for data screening and description. Before formally processing the data, an author (RXX) checked the legibility and completeness of the data. Any extraneous variables that must be controlled for and any potential problems in the data collection process were identified and avoided. Two other authors (YLL and TYM) independently performed data cleaning for outliers. Target data were transcoded and interpreted according to the CLHLS data coding guidelines (available at https://opendata.pku.edu.cn/dataverse/CHADS). All measurement data were recorded according to Supplementary Table 1 and imported into SPSS 25.0 (SPSS Inc., Chicago, IL, US) software for data analysis. Statistical analysis was performed using SPSS 25.0 (SPSS Inc., Chicago, IL, US). A chi-square test was applied to the association between independent, control, and moderator variables and depressive symptoms. A binary logistic regression adjusting for all confounding factors was conducted to compare the strength of the relationship between different living arrangements and depressive symptoms. Living arrangements and outdoor activities were sequentially included in the regression model to explore whether the association between living arrangements and depressive symptoms was affected after considering participation in outdoor activities. In addition, an interaction group for living arrangements and outdoor activities was introduced to determine whether outdoor activities moderated the independent and dependent variables.

P-values < 0.05 were considered statistically significant in this study.

Results

Sample characteristics

Table 1 presents the descriptive data for the sample and evaluates the odds risk (OR) value of depressive symptoms in control and independent variable groups. A total of 12,200 participants were included in this study, 46.5% of whom were male and 53.5% female, with a mean age of 83.39 ± 11.02 years. Most of the participants lived in rural areas (76.5%), had an agricultural hukou (70.8%), had < 9 years of education (89.5%), and had lost their spouses (52.2%). Regarding the individual health status, 18.5% of respondents reported disabilities and 63.1% had one or more chronic diseases. Furthermore, 79.9, 16.8, and 3.3% of the respondents lived with household members, alone, and in eldercare institutions, respectively. Moreover, 30.4% of the older people did not engage in any outdoor activities, whereas 39.5% of the older people who participated in outdoor activities maintained the habit almost once daily.

Associations between living arrangements and depressive symptoms

Table 1 shows the results of the univariate analyses performed to determine the distributions of depressive symptoms by relevant covariates and independent variables. Participants with the following characteristics were significantly associated with a higher risk of depressive symptoms (P < 0.05): female (OR = 1.33, 95%CI = 1.23–1.45), over 80 years old (OR = 1.47, 95%CI = 1.35–1.6), living in rural areas (OR = 1.41, 95%CI = 1.27–1.56), with agricultural hukou (OR = 1.39, 95%CI = 1.27–1.53), widowed (OR = 1.62, 95%CI = 1.49–1.76), and never married (OR = 3.21, 95%CI = 2.17–4.76). In addition, participants with fewer years of schooling, a higher number of chronic diseases, lower annual household income, higher levels of disability, and lower frequency of outdoor activities had higher risks of depressive symptoms (P < 0.05). Table 1 also presents more details.

Table 2 presents the binary logistic regression analysis results testing the relationship between living arrangements and depressive symptoms. After controlling for confounders (Model 1), participants living alone had a 1.26-times higher risk of depressive symptoms than those living with household members (adjusted odds ratio [AOR] = 1.26, 95%CI = 1.10–1.44, P = 0.001), while for those living in eldercare institutions, this risk was 1.39-times higher (AOR = 1.39, 95%CI = 1.09–1.77, P = 0.008). In Model 2, the results demonstrated that outdoor activities could significantly reduce the risk of depressive symptoms in respondents (AOR = 0.90, 95%CI = 0.87–0.92, P < 0.001). Moreover, the introduction of the outdoor activities variable in the model revealed that the risk of depressive symptoms increased to 1.31 times (95%CI = 1.14–1.50, P < 0.001) and 1.41 times (95%CI = 1.11–1.80, P = 0.006) for respondents living alone and those living in eldercare institutions, respectively.

Moderating effect of outdoor activities

The results in Table 3 demonstrated the risk of depressive symptoms for the interaction groups of different living arrangements and outdoor activities. The binary regression model demonstrated a strong interaction effect between living arrangements and outdoor activities with regard to depressive symptoms. Overall, participants who never engaged in outdoor activities and lived in eldercare institutions were 2.04 times more likely to experience depressive symptoms (95%CI = 1.44–2.9, P < 0.001) than participants who had a habit of participating in outdoor activities and lived with household members, and those who never participated in outdoor activities and lived alone were 1.69 times more likely to experience depressive symptoms (95%CI = 1.35–2.13, P < 0.001). Figure 1 depicts the AOR values of depressive symptoms for different interaction groups after controlling for all covariates.

Discussion

This study used a national-level survey database to determine the relationship between living arrangements and depressive symptoms among 12,200 Chinese people aged over 65 years. It explored the moderating effect of outdoor activities on both these variables. The main findings of this study indicated that participants living alone and those living in eldercare institutions had a significantly higher risk of depressive symptoms than those living with household members, and outdoor activities were effective in eliminating the risk of depressive symptoms caused by different living arrangements. These findings provide compelling evidence for future government decision-making on promoting active and healthy aging.

This study was not the first to explore the relationship between living arrangements and depressive symptoms. Some empirical studies conducted in South Korea, Singapore, and Japan have discovered that living alone is an independent risk factor contributing to depressive symptoms (30–32), which was consistent with this study's findings. Some in-depth studies based on other perspectives compared the risk of depressive symptoms in elder adults living with different household members and revealed that living with children was negatively

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TABLE 1 General characteristics of the participants by the occurrence of depressive symptoms and their unadjusted odds risk.

Category	Total (%)	Depressive symptoms (*n*)		Crude OR (95%CI)
		No (9060)	Yes (3140)	*P*
Age				<0.001
65–80	5297 (43.4)	4150	1147	1
80<	6903 (56.6)	4910	1993	1.47 (1.35–1.60)*
Gender				<0.001
Male	5667 (46.5)	4374	1293	1
Female	6533 (53.5)	4686	1847	1.33 (1.23–1.45)*
Living location				<0.001
Urban	2871 (23.5)	2269	602	1
Rural	9329 (76.5)	6791	2538	1.41 (1.27–1.56)*
Hukou status				<0.001
Non–agricultural	3560 (29.2)	2798	762	1
Agricultural	8623 (70.8)	6250	2373	1.39 (1.27–1.53)*
Households income				<0.001
<10000	3016 (25.8)	2052	964	1
10000–50000	3721 (31.8)	2788	933	0.71 (0.64–0.79)*
50000–100000	2705 (23.1)	2045	660	0.69 (0.61–0.77)*
>100000	2257 (19.3)	1823	434	0.51 (0.45–0.58)*
Marital status				<0.001
Married and living with spouse	5402 (44.7)	4283	1119	1
Married and living without spouse	224 (1.9)	174	50	1.10 (0.80–1.52)
Divorced	45 (0.4)	32	13	1.56 (0.81–2.97)
Widowed	6304 (52.2)	4431	1873	1.62 (1.49–1.76)*
Never married	103 (0.9)	56	47	3.21 (2.17–4.76)*
Years of schooling				<0.001
0	4656 (44.3)	3225	1431	1
1–9	4758 (45.2)	3722	1036	0.63 (0.57–0.69)*
10–	1103 (10.5)	883	220	0.56 (0.48–0.66)*
Disability				<0.001
No	9947 (81.5)	7608	2339	1
Mild	1341 (11.0)	930	411	1.44 (1.27–1.63)*
Moderate	490 (4.0)	294	196	2.17 (1.8–2.61)*
Severe	422 (3.5)	228	194	2.77 (2.27–3.37)*
Number of chronic diseases				<0.001
0	4496 (36.9)	3439	1057	1
1	4056 (33.2)	3060	996	1.6 (0.96–1.17)
2	2072 (17.0)	1491	581	1.27 (1.13–1.43)*
3	928 (7.6)	662	266	1.31 (1.12–1.53)*
≥4	648 (5.3)	408	240	1.91 (1.61–2.28)*
Living arrangement				<0.001
With household members	9747 (79.9)	7401	2346	1
Alone	2050 (16.8)	1394	656	1.49 (1.34–1.65)*
Elderly institution	403 (3.3)	265	138	1.64 (1.33–2.3)*
Outdoor activities				<0.001
0	3711 (30.4)	2515	1196	1
1	849 (7.0)	591	258	0.92 (0.78–1.80)
2	754 (6.2)	548	206	0.79 (0.66–0.94)*
3	2064 (16.9)	1526	538	0.74 (0.66–0.84)*
4	4822 (39.5)	3880	942	0.51 (0.46–0.56)*

*$P < 0.05$; OR, odds rate.

TABLE 2 Binary logistic regression for the association between living arrangements and depressive symptoms.

Variables	Model 1			Model 2		
	AOR	95%CI	*P*	AOR	95%CI	*P*
Age	1.07	0.96–1.20	0.224	1.01	0.90–1.14	0.825
Hukou status	1.13	0.95–1.34	0.168	1.12	0.95–1.33	0.178
Living location	1.24	1.03–1.48	0.021	1.25	1.05–1.50	0.015
Gender	1.05	0.95–1.17	0.352	1.06	0.95–1.18	0.294
Household income	0.84	0.80–0.89	<0.001	0.85	0.81–0.89	<0.001
Marital status	1.07	1.03–1.12	0.001	1.07	1.03–1.11	0.001
Years of schooling	0.87	0.79–0.95	0.002	0.88	0.81–0.97	0.006
Number of chronic diseases	1.22	1.17–1.27	<0.001	1.22	1.17–1.28	<0.001
Disability	1.37	1.29–1.46	<0.001	1.28	1.20–1.37	<0.001
Living arrangements						
With household members	Ref.	/	/	Ref.	/	/
Alone	1.26	1.10–1.44	0.001	1.31	1.14–1.50	<0.001
Elderly institution	1.39	1.09–1.77	0.008	1.41	1.11–1.80	0.006
Outdoor activities				0.90	0.87–0.92	<0.001

Model 1, controlling for age, Hukou status, gender, living location, marital status, household income, years of schooling, number of chronic diseases, disability. Model 2, introducing outdoor activities variable on the basis of Mode 1. AOR, adjusted odds rate. Reference, compare to living with household members Ref., Reference.

TABLE 3 Measuring the moderating effect of outdoor activities on living arrangements and depressive symptoms.

Interaction group	Total (%)	B	SE	AOR	95%CI	*P*
Living with household members ×Have outdoor activities	6733 (55.19)	Ref.	Ref.	Ref.	Ref.	Ref.
Living with household members ×No outdoor activities	3014 (24.70)	0.226	0.062	1.254	1.11–1.41	<0.001
Living alone ×Have outdoor activities	1534 (12.57)	0.196	0.081	1.216	1.04–1.43	0.015
Living alone ×No outdoor activities	516 (4.29)	0.527	0.116	1.694	1.35–2.13	<0.001
Living in elderly institution ×Have outdoor activities	222 (1.82)	0.143	0.179	1.153	0.81–1.64	0.426
Living in elderly institution ×No outdoor activities	181 (1.48)	0.715	0.178	2.044	1.44–2.90	<0.001

controlling for age, Hukou status, gender, living location, marital status, household income, years of schooling, number of chronic diseases, disability. B, regression coefficient; SE, standard error; AOR, adjusted odds rate.

associated with elders' depressive symptoms (33, 34). All evidence suggested that living with household members was a protective factor against depressive symptoms. In addition, this study's results suggested a 34.2% prevalence of depressive symptoms among the elderly living in Chinese eldercare institutions. The mental health issues of this population have gradually aroused the interest of researchers in other countries and regions. Previous studies from Taiwan, Brazil, and the United States also reported a high prevalence of depression in this population (36–54.8%) (35–37). However, no empirical study had reported the risk of depressive symptoms among older adults choosing to enroll in eldercare institutions than other living arrangements, based on this study's rigorous literature search.

China currently faces a huge demand for elderly care services, which will gradually grow with the increasingly severe issue of population aging and the shortage of family caregivers (from 1982 to 2016, China had the peculiar 4-2-1 family structure where a couple could only have one child) (38). However, this study's results revealed that eldercare institutions are not a good alternative for the mental health of the elderly. In fact, the risk of depressive symptoms among the elderly living in eldercare institutions was 1.41 times higher than that among those living with household members. Differences in the depressive risk for different living arrangements could be explained or speculated for the following reasons. First, the traditional family-centered culture in China makes the elderly reluctant to leave their familiar house (even if they live alone) (39). A study conducted in the Zhejiang Province (China) discovered that only 3.8% of elderly adults were willing to enroll in an eldercare facility. This change in the living environment and their rejection psychology (maybe a stigma (13)) might be potential risk factors for depressive symptoms. Second, the noise pollution, crowding, and cramped indoor

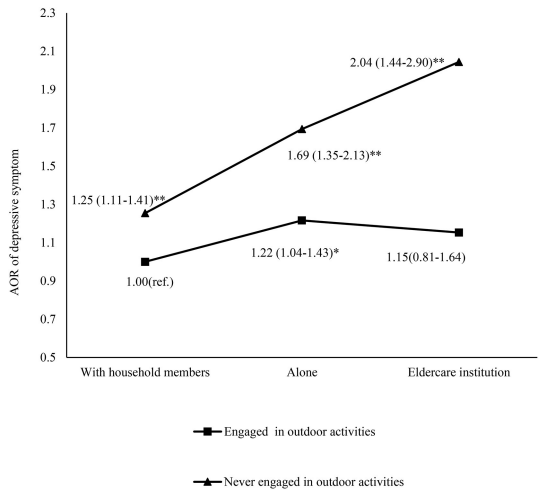

FIGURE 1
Interaction effects of outdoor activities and living arrangements in depression. (Logistic regression analysis controlling for age, Hukou status, gender, living location, marital status, household income, years of schooling, number of chronic diseases, and disability; * $P<0.05$; ** $P<0.001$; ref., reference; AOR, adjusted odds rate).

activity spaces of some eldercare institutions in China might contribute to the depressive symptoms of older adults. Some Chinese eldercare institutions face severe noise pollution and the lack of adequate indoor activity space because of irrational site selection and renovations from other-use buildings (40, 41). Moreover, several community eldercare institutions arrange for multiple people to live in one room. This lack of personal privacy and noisy space reduces the elderly people's quality of sleep. In previous investigations, these negative factors were found to be significantly associated with depressive symptoms (42, 43). Third, many elderly Chinese people regard living in an eldercare institution as "the last journey in their lives." As the older adults around them die one after another, they feel like there is a countdown to their lives, making them pessimistic (44). Fourth, some eldercare institutions in China lack functional mental health services, and the caregivers working in these institutions hardly pay attention to the clients' mental health in their daily work. This deficiency is directly related to the shortage, old age, and low education level of the caregivers (45).

A key finding of this study suggested that outdoor activities, as a moderator between different living arrangements and depressive symptoms, reduced and eliminated the risk of depressive symptoms associated with older Chinese adults living alone and in eldercare institutions, respectively. Previous empirical studies have proven that outdoor activities were an effective measure for preventing depressive symptoms (46, 47). This study did not thoroughly explore the mechanisms of the moderating effect of outdoor activities between living arrangements and depression. However, the mechanism by which outdoor activities ameliorates depression is relatively clear. It can be viewed as a blend of strategies that include environmental factors (bright light, fresh air, green space, and ample space for activity), individual factors (increased physical activity), and social factors (increased socialization) (16, 17). This study included the types of outdoor activities that are generally preferred by the elderly in China, such as Tai Chi and square dancing, among others. Tai Chi is a way of improving immunity in traditional Chinese medicine. A systematic review and meta-analysis pooling 37 relevant randomized controlled trials showed that Tai Chi interventions exerted beneficial effects for various populations with regard to depressive symptoms (48). Tai Chi is a series of meditative movements. An earlier study demonstrated that meditation can alleviate several stress-related emotional symptoms by activating the parasympathetic nervous system (49). Similarly, square dancing reduced depressive symptoms in older adults, which has also been reported in previous intervention studies (50). Square dancing may reduce depression risk through socialization and exercises. Although this study advocated that elderly people living alone or in eldercare institutions should actively participate in outdoor activities to prevent depressive symptoms, it should also be remembered that each elder adult needs to select suitable activities according to their health status (because some patients are advised not to participate in outdoor activities).

This study had several limitations. First, it did not consider how long participants had lived alone or in eldercare institutions. This provision might interfere with this study's results as the risk of depressive symptoms may differ among participants with different event durations. Second, it did not categorize the outdoor activities the participants engaged in, which would affect the interpretation of the results. Third, the older people in this study living in eldercare intuitions accounted for only 3.3% of the total sample (403 cases), which may have biased the results. However, this study used a comprehensive analysis to avoid these biases.

Practical implications

This study's results have practical implications for Chinese governments and organizers of future eldercare institutions in selecting the building sites and planning the internal organization and work content settings. First, the caregivers of the institutions should encourage and organize the elderly to participate in outdoor activities and cultivate their interests in some outdoor activities. Second, prioritizing the locations of eldercare institutions away from commercial areas and close to parks and squares can reduce the exposure of the elderly to noise pollution and facilitate their participation in outdoor activities. Third, eldercare institutions should pay more attention to the mental health of older adults and should not limit their services

to physical care; they can do this, for example, by setting up psychological counseling rooms. Fourth, those who make the designs of the internal environments of the eldercare institutions should consider the characteristics of the elderly as much as possible; for example, they should plan for bright light, quietness, personal privacy protection, and sufficient indoor activity space.

Conclusion

This study suggests that the elderly living alone and those living in eldercare institutions are significantly more likely to have depressive symptoms than those living with household members. In addition, outdoor activities play a moderating role between different living arrangements and depressive symptoms. In future work, community or eldercare institution staff need to encourage older people, especially those living alone or in eldercare institutions, to actively participate in the outdoor activities suitable for them.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://opendata.pku.edu.cn/dataverse/CHADS.

Ethics statement

The studies involving human participants were reviewed and approved by Biomedical Ethics Review Committee of Peking University(IRB00001052–13074). The patients/participants provided their written informed consent to participate in this study.

Author contributions

RX and CX designed the study and assessed the quality of the studies and wrote the first draft of the manuscript. YL and RX conducted data analysis. CX monitored article quality and language polish. YL, YY, and TM extracted the data from CLHLS according to the inclusion criteria and proofread these data. All authors contributed to and have approved the final manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.954416/full#supplementary-material

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Psychological effects and associated factors among vaccinated and unvaccinated general population against COVID-19 infection in Bangladesh

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Background: The global effort to develop herd immunity in the general public against the COVID-19 pandemic is currently ongoing. However, to the best of our knowledge, there have been no studies on how the COVID-19 vaccine affects mental health in the context of the COVID-19 pandemic in Bangladesh. The present study investigated the psychological effects and associated factors among vaccinated and unvaccinated general populations against COVID-19 infection in Bangladesh.

Methods: A nationwide online cross-sectional survey was conducted in Bangladesh from June 23 to December 25, 2021. The frequency of symptoms of psychological distress, depression, anxiety, stress, post-traumatic stress disorder (PTSD), insomnia, and fear was assessed using the Bangla versions of the GHQ-12, PHQ-2, GAD-2, PSS-4, PC-PTSD-5, ISI, and FCV-19S scales, respectively.

Results: The study included 3,013 persons from all eight divisions of Bangladesh, with 1,272 (42.2%) being vaccinated and 1,741 (57.8%) being unvaccinated. Compared with unvaccinated populations, vaccinated populations had significantly lower prevalence rates of psychological distress (36.4 vs. 51.5%), depression (21.1 vs. 37.9%), anxiety (25.1 vs. 44.9%), stress (19.4 vs. 30.4%), PTSD (29.4 vs. 38.3%), insomnia (18.7 vs. 39.4%), and fear symptoms (16.1 vs. 27.5%). Among vaccinated populations, respondents who lived in nuclear families were significantly associated with higher risk of psychological distress (AOR, 1.38; 95% CI, 1.09–1.78), depression (AOR, 1.49; 95% CI, 1.11–1.98), anxiety (AOR, 1.77; 95% CI, 1.21–1.98), and fear (AOR, 1.43; 95% CI, 1.11–1.83) symptoms. Participants who lost family members, friends, or colleagues due to the COVID-19 pandemic had significantly higher risk of symptoms of psychological distress (AOR, 1.35; 95% CI, 1.02–1.79), anxiety (AOR, 1.41;

95% CI, 1.11–1.87), and PTSD (AOR, 1.76; 95% CI, 1.24–2.19). On the other hand, unvaccinated populations who lived in the Dhaka division were significantly associated with an increased risk of depression (AOR, 2.06; 95% CI, 1.40–2.52), anxiety (AOR, 1.86; 95% CI, 1.15–2.47), stress (AOR, 1.92; 95% CI, 1.12–2.88), and insomnia (AOR, 1.88; 95% CI, 1.20–2.94) symptoms. Except for PTSD and fear symptoms, unemployed participants had considerably higher rates of psychological distress, depression, anxiety, stress, and insomnia symptoms (e.g., psychological distress: AOR, 1.83; 95% CI, 1.10–2.62; depression: AOR, 1.74; 95% CI, 1.37–2.19).

Conclusions: This study recommends immunizing unvaccinated populations as soon as possible to prevent infection and boost mental health. Vulnerable people needed special care, health-related education, and psychological assistance.

KEYWORDS

Bangladesh, COVID-19, general populations, immunization, psychological effects, refusal, uptake

Introduction

Since the commencement of the Coronavirus Disease 2019 (COVID-19) pandemic in 2019, more than 536 million people from 225 countries have been infected with the virus. Approximately 6.3 million people passed away (as of June 19, 2022) (1). To prevent the epidemic from spreading further, all governments have established mandatory measures including containment, quarantine, community control, and business and school closures (2–4). As a result of this large-scale contagious public health calamity and significant disruptions in daily life, people are under a lot of stress. They are experiencing a lot of mental health problems (5). In previous epidemiological studies, survivors of the severe acute respiratory syndrome (SARS), middle east respiratory syndrome (MERS), and Ebola virus disease (EVD) outbreaks reported depression, anxiety, negative psychological repercussions, panic attacks, psychomotor excitement, psychotic symptoms, loneliness, boredom, delirium, and even suicidal tendencies (6–9). According to a recent comprehensive review study, the prevalence of depression, anxiety, and post-traumatic stress disorder (PTSD) symptoms among SARS survivors were 19, 20, and 28%, respectively (10).

However, the estimates of psychological problems among the general public are higher than those for regular periods during the COVID-19 pandemic (11, 12). A recent systematic review of global (including 32 different countries and 398,771 participants) prevalence of mental health issues in the general population showed prevalence's of psychological distress, depression, anxiety, stress, PTSD, and sleep problems, at 50.0, 28.0, 26.9, 36.5, 24.1, and 27.6%, respectively (13). Another review study included 82 studies with a total of 96,100 participants showed that the overall prevalence of depression (23.9%), anxiety (23.4%), stress (14.2%), distress (16.0%), PTSD (24.9%), insomnia (26.5%), and poor mental health (26.5%) during the SARS and COVID-19 epidemics (14). Bangladesh, a densely populated and resource-limited country is confronted with widespread devastation and serious psychological issues during the COVID-19 outbreak (15). The first COVID-19 case was reported in Bangladesh on March 8, 2020, and as of June 19, 2022, the country had 1.95 million verified COVID-19 cases and 29,131 deaths (Supplementary Figures S1, S2) (16). Bangladesh is among the top 32 countries contributing to 0.56% of the COVID-19 cases in the world.

Like many countries, Bangladesh has employed various tactics to limit the spread of COVID-19, including lockdown, social distancing, self-isolation, and quarantine (17). The government announced a nationwide lockdown from March 26 to May 30, 2020, which was extended seven times (18, 19). In addition, until August 31, 2020, the government has imposed limits on public activities and movement across the country to prevent the spread of COVID-19 (20). As a result of the virus's ongoing spread and pandemic-related limits, the general public is progressively experiencing various types of psychological distress. According to previous studies, many people acquired psychological symptoms during the COVID-19 pandemic, including depression, anxiety, stress, panic attacks, sleep problems, and even suicidal ideation (21–23). During the early stages of the COVID-19 pandemic, a statewide survey of 1,427 persons in Bangladesh found that 57.9% of participants experienced depression, 33.7% had anxiety, and 59.7% had stress (24).

Vaccination has quickly emerged as an important strategy for prevention in the current COVID-19 pandemic. High

vaccination coverage rates are necessary to protect the entire population indirectly. The global economy will reopen, and society will resume its regular routines, which is especially important given the present COVID-19 pandemic (25). High vaccination rates are also required to develop herd immunity, which minimizes COVID-19 transmission and infection risk in the general population and those most vulnerable to illness (26, 27). It has been estimated between 55 and 82% of populations would need to be vaccinated to reach herd immunity for COVID-19, depending on varying biological, environmental, socio-behavioral factors and infection rates within each country (28). Vaccine hesitancy, described as delayed acceptance, hesitation, or refusal of vaccination despite the availability of vaccination services, is a barrier to establishing herd immunity (27, 29).

The World Health Organization's strategy for achieving universal COVID-19 vaccination by mid-2022 lays out the path we must all take together to meet the goals of vaccinating 40% of the population of each country by the end of 2021 and 70% by the middle of 2022 (30). Bangladesh started distributing COVID-19 vaccinations on January 27, 2021, with bulk immunization beginning on February 7, 2021, and the second dosage starting on April 8, 2021. As of June 19, 2022, the number of first doses administered in Bangladesh exceeds 128,943,393 (75.7% of the total population), and the number of second doses administered exceeds 118,629,297 (69.7% of the total population) (Supplementary Figure S3) (31). With such a large number of volunteers being vaccinated, their psychological wellbeing should be examined as well. Even though COVID-19 vaccinations are safe for most persons over the age of 18, uncommon adverse effects still occur. After immunization, moderate side effects such as arm discomfort, slight fever, weariness, and headaches have been noted (32, 33). Furthermore, vaccine efficacy had not been well-validated in the general public before mass immunizations, and controversy about efficacy lingered even among those vaccinated (34).

A nationally representative Understanding America Study (UAS) of 8,003 adults in the United States discovered that people experienced lower distress levels after receiving the first dose of the COVID vaccination (35). Another study conducted in China discovered that stress levels dramatically lowered after vaccination (36). Moreover, a study conducted among 1,779 adults in Germany between January 1, 2021, to January 11, 2021, showed that COVID-19 vaccination could positively correlate with COVID-19-related anxiety and fears (37). Furthermore, a survey of 250 Jordanians who received their first dose of the COVID-19 vaccine by Al-Amer et al. (38) revealed that the vaccine is a source of distress for those who receive it for the first time, with higher levels of stress and anxiety after vaccination among those who experienced normal levels of anxiety before vaccination. Individuals with certain conditions (e.g., chronic disease such as psoriasis) as well as those intensively exposed to vaccine-related conspiracy beliefs may develop distress symptoms following vaccination. However, to our knowledge, there have been no studies on the psychological effects of COVID-19 vaccination among both vaccinated and unvaccinated general populations in Bangladesh yet. Therefore, we conducted a cross-sectional nationwide survey to assess the psychological effects and associated factors among the vaccinated and unvaccinated general population against SARS-CoV-2 infection in Bangladesh. The goal of this study opted to examine the prevalence of psychological distress, depression, anxiety, stress, PTSD, insomnia, and fear symptoms among the vaccinated and unvaccinated people against SARS-CoV-2 infection in Bangladesh and explored its contributing factors. This research will add to our understanding, describe, and address the general public's change in psychological effects after receiving the COVID-19 vaccine. It may also assist the government and policymakers in providing comprehensive and accurate information to those who are hesitant or resistant to vaccination and boost their confidence in the ongoing vaccination campaign.

Materials and methods

Study design

A cross-sectional design was utilized to perform this study. The study protocol was reviewed and approved by the Department of Psychology, Jagannath University, Dhaka, Bangladesh (JnU/DoP/206021), and the Ethics Committee of the First Affiliated Hospital, Zhejiang University School of Medicine, Hangzhou, China (IIT20220190B). The criteria for inclusion were as follows: (1) possessing the following requirements: being at least 18 years old, (2) residing in Bangladesh at the time of the COVID-19, (3) being willing to participate in this study by providing online informed consent, (4) completing the entire questionnaire, (5) not having a history of mental health issues, and (6) getting the second dose of the COVID-19 vaccines.

Participants

The sample size was calculated using OpenEpi software. A prior investigation of the SARS-CoV-2 outbreak in Bangladesh discovered that about half of the people had psychological issues (24). This 50% proportion would provide maximum variance and sample size. At 95% confidence level, 80% power, and 2.5 design effect, we arrived at a sample size of 960. The estimated sample was 1,920, assuming an equal number of respondents ($n = 960$) in the vaccinated and unvaccinated subsamples. However, assuming a non-response rate of 10%, the final sample size decided in the current study was 2,112, with 1,056 respondents in each subsample.

Procedure

A nationwide online study using Google Forms and the Bangla language was done from June 23 to December 25, 2021. The goal of this study was mentioned on the first page of the online form, and all participants' consent was ensured on that page. The five research assistants distributed the poll link *via* e-mail, Facebook, Viber, WhatsApp, Imo, and other social media sites. Participants were encouraged to complete the form and share the link with their networks to reach a larger audience. The five research assistants used convenient and snowball sampling to circulate the survey link throughout their professional and social networks. Participants were instructed that participating in the study was completely voluntary and that they should share the survey link with their colleagues or friends once they finished it. All participants were given assurances about the privacy and confidentiality of their information and the ability to have their data removed at any time. The current study received a total of 3,064 responses at the onset. After screening, 51 responses were eliminated due to incomplete information, the first dose vaccinated, under 18 years old, and being outside of Bangladesh. Finally, responses from 3,013 general populations were included in this study. A total of 3,013 Bangladeshi people completed the questionnaire, with 1,272 (42.2%) vaccinated and 1,741 (57.8%) unvaccinated.

Measurements

Demographic, health, and COVID-19-related information

The participant's sex (male or female), age (18–29, 30–39, 40–49, 50–59 or ≥60 years), divisions (Dhaka, Chittagong, Barisal, Khulna, Rajshahi, Rangpur, Mymensingh, or Sylhet), residence (urban or rural), nature of family (nuclear or joint), educational level (college/below or university/higher) were self-reported demographic characteristics. Participants were asked about their status of marriage, whether or not they had children, occupation (student, unemployed, employed, businessman, housewife, or other), and socioeconomic status (lower, middle or upper class). In addition, participants were also asked to provide health, behavior, and COVID-19-related information (yes or no). Such as daily physical exercise, smoking habit, current alcohol drinking behavior, daily social media use, whether participants had been infected with COVID-19, whether anyone in their family members, friends, or colleagues had been infected with COVID-19, and whether anyone in their family members, friends, or colleagues had died from COVID-19.

General health questionnaire

The Bangla version of the twelve-item General Health Questionnaire (GHQ-12) (39, 40) evaluates psychological distress on a four-point Likert scale, with "1" defining never and "4" defining frequently. For a full score of 0 to 12, each item can be assigned a value of 0 (if option 1 or 2) or 1 (if options 3 and 4). An overall score $\geq$ 3 indicates a clinically significant level of poor mental health status. Its reliability in the current sample is very good (coefficient alpha = 0.80).

Patient health questionnaire

The Bangla version of the two-item Patient Health Questionnaire (PHQ-2) (41, 42) evaluates depression symptoms rated on a four-point Likert scale, with "1" defining never and "4" defining almost every day. The total score ranges from 0 to 6. An overall score $\geq$ 3 indicates a clinically significant level of depression. Its reliability in the present study is acceptable (coefficient alpha = 0.72).

Generalized anxiety disorder scale

The Bangla version of the two-item Generalized Anxiety Disorder scale (GAD-2) (43, 44) evaluates anxiety symptoms on a four-point Likert scale, with "1" defining never and "4" defining almost every day. The total score ranges from 0 to 6. An overall score $\geq$ 3 indicates a clinically significant level of anxiety. Its reliability in the current sample is very good (coefficient alpha = 0.84).

Perceived stress scale

The Bangla version of the four-item Perceived Stress Scale (PSS-4) (45, 46) evaluates stress symptoms on a four-point Likert scale, with "1" defining never and "4" defining always. The total score ranges from 0 to 16. An overall score $\geq$ 9 indicates a clinically significant level of stress. Its reliability in the present study is acceptable (coefficient alpha = 0.71).

Primary care PTSD screen for DSM-5

The Bangla version of the five-item Primary Care PTSD Screen for DSM-5 (PC-PTSD-5) (47, 48) evaluates post-traumatic stress disorder symptoms over the past month by asking five binary questions about re-experiencing, avoidance, physiological reactions, emotional numbness, and trauma-distorted guilt and blame thoughts. This scale was previously used in a Bangladeshi study. The total score ranges from 1 to 5. An overall score $\geq$ 3 indicates a clinically significant level of post-traumatic stress disorder. Its reliability in the current sample is acceptable (coefficient alpha = 0.75).

Insomnia severity index

The Bangla version of the seven-item Insomnia Severity Index (ISI) (49, 50) evaluates the severity of insomnia on a five-point Likert scale, with "0" defining no problem and "4" defining a major problem. The total score ranges from 0 to 28. An overall score ≥ 8 indicates a clinically significant level of insomnia. Its reliability in the present study is acceptable (coefficient alpha $= 0.74$).

Fear of COVID-19 scale

The Bangla version of the seven-item Fear of COVID-19 Scale (FCV-19S) (51, 52) evaluates the level of fear associated with COVID-19 on a five-point Likert scale, with "1" defining strongly disagree and "5" defining strongly agree. The total score ranges from 7 to 35. An overall score ≥ 18 indicates a clinically significant level of COVID-19-related fear. Its reliability in the current sample is very good (coefficient alpha $= 0.89$).

Oslo social support scale

The Bangla version of the three-item Oslo Social Support Scale (OSSS-3) evaluates respondents' social support (48, 53). The sum score ranges from 3 to 14, with high values representing strong levels and low values representing poor levels of social support. Social support has been leveled as poor, moderate, or strong based on a score of 3–8, 9–11, or 12–14. The reliability of the OSSS-3 in this study is acceptable (coefficient alpha $= 0.79$).

Statistical analysis

The statistical analyses were run by SPSS version 20.0, and figures were prepared in GraphPad Prism version 9. Categorical data was represented using numbers and percentages. To compare categorical variable variations between groups, Chi-square tests were used. The Kolmogorov–Smirnov test, the Shapiro–Wilk test, and normal Q-Q plots were used to determine the data's normality. The median of the interquartile range (IQR) of data from non-normal distributions was shown. When comparing non-normally distributed data between two groups, the Mann–Whitney *U*-test was used, and when comparing data between more than two groups, the Kruskal–Wallis-test was used. Spearman correlations were used to compare the psychological effects of vaccinated and unvaccinated populations. In addition, binary logistic regression analysis was used to examine potential predictors of psychological effects in both groups. The model fitness test was checked using the Hosmer and Lemeshow goodness of fit test. All of the variables were added in the univariate analysis. Then the multivariate analysis only included the significant variables in the univariate analysis after controlling for confounders (e.g., sex, age, divisions, residence, etc.). For a single predictor, univariate analysis expressed as crude odds ratio (COR) was used, while multivariate analysis expressed as adjusted odds ratio (AOR) was used for multiple predictors, and psychological effects were considered dependent variables. All analyses were conducted at a 95% confidence level, with p-values equal to or <0.05 considered significant.

Results

Demographic, health, and COVID-19-related characteristics

Finally, 3,013 general populations were enrolled in our study, with 1,272 (42.2%) being vaccinated and 1,741 (57.8%) being unvaccinated. The demographic, health, and COVID-19-related characteristics of the study participants are shown in Table 1. Vaccinated populations were significantly more likely to be Dhaka division (56.8 vs. 28.9%, $p = 0.00$), be married (75.5 vs. 65.8%, $p = 0.00$), having children (48.3 vs. 38.1%, $p = 0.00$), smoke (33.5 vs. 24.0%, $p = 0.00$), have chronic diseases (31.1 vs. 7.9%, $p = 0.00$), daily social media used (43.3 vs. 29.4%, $p = 0.00$), be infected with COVID-19 (39.5 vs. 26.3%, $p = 0.00$), have family members, friends, or colleagues infected with COVID-19 (45.8 vs. 32.1%, $p = 0.00$), have family members, friends, or colleagues died from COVID-19 (32.2 vs. 24.6%, $p = 0.00$), and moderate social support (60.9 vs. 45.1%, $p = 0.00$) than unvaccinated populations. On the other hand, unvaccinated populations were significantly more likely to be male (66.2 vs. 56.4%, $p = 0.00$), 30–39 years old (60.0 vs. 58.8%, $p = 0.00$), and have a joint family (64.9 vs. 60.5%, $p = 0.02$) than vaccinated populations. However, there were no significant differences between the vaccinated and unvaccinated populations in terms of residence ($p = 0.06$), education level ($p = 0.06$), occupation ($p = 0.17$), socioeconomic status ($p = 0.61$), physical exercise ($p = 0.52$), and current alcohol drinking behavior ($p = 0.18$).

Scores of psychological effects

Table 2 shows the median of the IQR of psychological effects scores in vaccinated and unvaccinated populations against COVID-19 infection. When compared to unvaccinated populations, vaccinated populations had significantly lower median of the IQR of scores for depression (1.0 [1.0–2.0] vs. 3.0 [1.0–4.0]; $p = 0.00$), anxiety (2.0 [1.0–3.0] vs. 3.0 [1.0–4.0]; $p = 0.00$), stress (1.0 [7.0–8.0] vs. 6.0 [4.0–10.0]; $p = 0.00$), insomnia (3.0 [4.0–7.0] vs. 7.0 [4.0–11.0]; $p = 0.00$), and fear (7.0 [9.0–16.0] vs. 10.0 [9.0–19.0]; $p = 0.01$) symptoms, but significantly same median of the IQR of scores for psychological distress symptoms. However, the IQR of scores for PTSD symptoms

TABLE 1 Demographic, health, and COVID-19-related characteristics in vaccinated and unvaccinated populations against COVID-19 infection.

Characteristics	Total ($n = 3,013$)	Vaccinated population ($n = 1,272$)	Unvaccinated population ($n = 1,741$)	χ^2	df	p-value
	No. (%)	No. (%)	No. (%)			
Sex						
Male	1,870 (62.1)	718 (56.4)	1,152 (66.2)	29.50	1	0.00
Female	1,143 (37.9)	554 (43.6)	589 (33.8)			
Age, y						
18–29	448 (14.9)	166 (13.1)	282 (16.2)	14.26	4	0.00
30–39	1,792 (59.5)	748 (58.8)	1,044 (60.0)			
40–49	647 (21.5)	293 (23.0)	354 (20.3)			
50–59	96 (3.2)	53 (4.2)	43 (2.5)			
≥60	30 (1.0)	12 (0.9)	18 (1.0)			
Divisions of Bangladesh						
Dhaka	1,226 (40.7)	722 (56.8)	504 (28.9)	254.93	7	0.00
Chittagong	415 (13.8)	152 (11.9)	263 (15.1)			
Barisal	294 (9.8)	80 (6.3)	214 (12.3)			
Khulna	365 (12.1)	129 (10.1)	236 (13.6)			
Rajshahi	196 (6.5)	50 (3.9)	146 (8.4)			
Rangpur	221 (7.3)	56 (4.4)	165 (9.5)			
Mymensingh	115 (3.8)	25 (2.0)	90 (5.2)			
Sylhet	181 (6.0)	58 (4.6)	123 (7.1)			
Residence						
Urban	1,805 (59.9)	737 (57.9)	1,068 (61.3)	3.54	1	0.06
Rural	1,208 (40.1)	535 (42.1)	673 (38.7)			
Family type						
Nuclear	1,114 (37.0)	503 (39.5)	611 (35.1)	6.24	1	0.02
Joint	1,899 (63.0)	769 (60.5)	1,130 (64.9)			
Education level						
College/below	1,069 (35.5)	427 (33.6)	642 (36.9)	3.51	1	0.06
University/higher	1,944 (64.5)	845 (66.4)	1,099 (63.1)			
Marital status						
Single	716 (23.8)	258 (20.3)	458 (26.3)	36.76	2	0.00
Married	2,105 (69.9)	960 (75.5)	1,145 (65.8)			
Divorced/separated/widowed	192 (6.4)	54 (4.2)	138 (7.9)			
Having children						
Yes	1,279 (42.4)	615 (48.3)	664 (38.1)	31.36	1	0.00
No	1,734 (57.6)	657 (51.7)	1,077 (61.9)			
Occupation						
Student	227 (7.5)	103 (8.1)	124 (7.1)	7.76	5	0.17
Unemployed	156 (5.2)	72 (5.7)	84 (4.8)			
Employed	1,587 (52.7)	652 (51.3)	935 (53.7)			
Businessman	347 (11.5)	143 (11.2)	204 (11.7)			
Housewife	102 (3.4)	54 (4.2)	48 (2.8)			
Other	594 (19.7)	248 (19.5)	346 (19.9)			
Socioeconomic status						
Lower	208 (6.9)	87 (6.8)	121 (7.0)			
Middle	801 (26.6)	350 (27.5)	451 (25.9)	0.97	2	0.61
Upper	2,004 (66.5)	835 (65.6)	1,169 (67.1)			

(Continued)

TABLE 1 Continued

Characteristics	Total ($n = 3,013$)	Vaccinated population ($n = 1,272$)	Unvaccinated population ($n = 1,741$)	χ^2	df	p-value
	No. (%)	No. (%)	No. (%)			
Physical exercise						
Yes	825 (27.4)	356 (28.0)	469 (26.9)	0.40	1	0.52
No	2,188 (72.6)	916 (72.0)	1,272 (73.1)			
Smoking habit						
Yes	843 (28.0)	426 (33.5)	417 (24.0)	33.18	1	0.00
No	2,170 (72.0)	846 (66.5)	1,324 (76.0)			
Alcohol use						
Yes	163 (5.4)	77 (6.1)	86 (4.9)	1.78	1	0.18
No	2,850 (94.6)	1,195 (93.9)	1,655 (95.1)			
Chronic diseases						
Yes	533 (17.7)	395 (31.1)	138 (7.9)	269.98	1	0.00
No	2,480 (82.3)	877 (68.9)	1,603 (92.1)			
Social media use						
Yes	1,062 (35.2)	551 (43.3)	511 (29.4)	62.81	1	0.00
No	1,951 (64.8)	721 (56.7)	1,230 (70.6)			
Have you been infected with COVID-19?						
Yes	961 (31.9)	503 (39.5)	458 (26.3)	59.29	1	0.00
No	2,052 (68.1)	769 (60.5)	1,283 (73.7)			
Have any of your family members, friends, or colleagues been infected with COVID-19?						
Yes	1,141 (37.9)	582 (45.8)	559 (32.1)	58.17	1	0.00
No	1,872 (62.1)	690 (54.2)	1,182 (67.9)			
Have any of your family members, friends, or colleagues died of COVID-19?						
Yes	839 (27.8)	410 (32.2)	429 (24.6)	21.08	1	0.00
No	2,174 (72.2)	862 (67.8)	1,312 (75.4)			
Social support						
Poor	911 (30.2)	330 (25.9)	581 (33.4)	77.92	2	0.00
Moderate	1,560 (51.8)	775 (60.9)	785 (45.1)			
Strong	542 (18.0)	167 (13.1)	375 (21.5)			

did not differ significantly between vaccinated and unvaccinated populations ($p = 0.23$).

Prevalence of psychological effects

The prevalence of psychological effects among vaccinated and unvaccinated populations against COVID-19 infection are shown in Figure 1 and Table 3. The prevalence rates of symptoms of psychological distress, depression, anxiety, stress, PTSD, insomnia, and fear symptoms among vaccinated populations were 36.4, 21.1, 25.1, 19.4, 29.4, 18.7, and 16.1%, respectively. On the other hand, the prevalence rates of symptoms of psychological distress, depression, anxiety, stress, PTSD, insomnia, and fear symptoms among unvaccinated populations were 51.5, 37.9, 44.9, 30.4, 38.3, 39.4, and 27.5%, respectively. However, these findings showed that vaccinated populations had significantly lower prevalence rates of psychological distress (36.4 vs. 51.5%, $p = 0.00$), depression (21.1 vs. 37.9%, $p = 0.00$), anxiety (25.1 vs. 44.9%, $p = 0.00$), stress (19.4 vs. 30.4%, $p = 0.00$), PTSD (29.4 vs. 38.3%, $p = 0.00$), insomnia (18.7 vs. 39.4%, $p = 0.00$), and fear symptoms (16.1 vs. 27.5%, $p = 0.00$) than unvaccinated populations.

Correlations of psychological effects

Spearman's correlations of psychological effects among vaccinated and unvaccinated populations are shown in Table 4.

TABLE 2 The median of the interquartile range (IQR) of psychological effects scores in vaccinated and unvaccinated populations against COVID-19 infection.

Psychological effects	Vaccinated population	Unvaccinated population	z score	*p*-value
	Median (IQR)	Median (IQR)		
Psychological distress symptoms	5.0 (1.0–6.0)	5.0 (1.0–6.0)	−5.64	0.00
Depression symptoms	1.0 (1.0–2.0)	3.0 (1.0–4.0)	−12.4	0.00
Anxiety symptoms	2.0 (1.0–3.0)	3.0 (1.0–4.0)	−7.61	0.00
Stress symptoms	1.0 (7.0–8.0)	6.0 (4.0–10.0)	−10.5	0.00
PTSD symptoms	3.0 (1.0–4.0)	3.0 (1.0–4.0)	−1.19	0.23
Insomnia symptoms	3.0 (4.0–7.0)	7.0 (4.0–11.0)	−12.6	0.00
Fear symptoms	7.0 (9.0–16.0)	10.0 (9.0–19.0)	−2.51	0.01

IQR, Interquartile range; PTSD, Post-traumatic stress disorder.

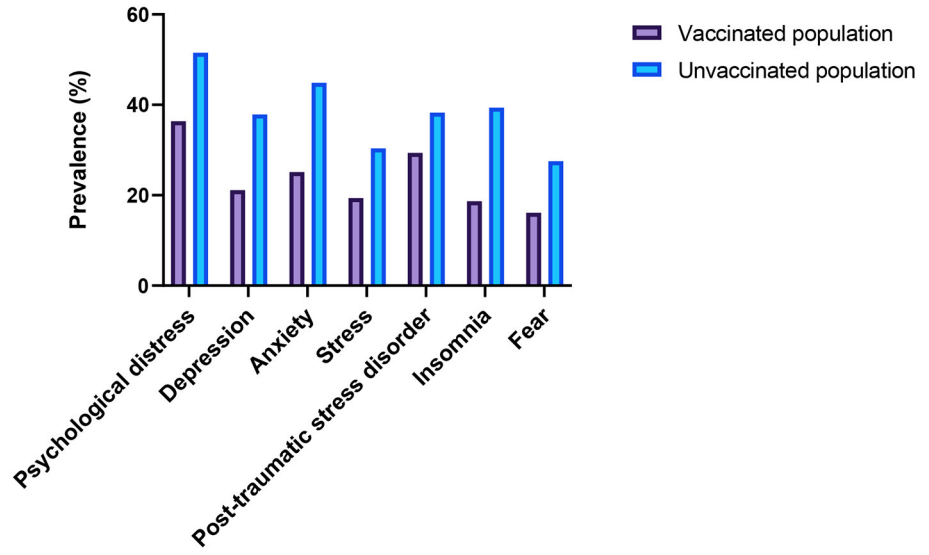

FIGURE 1
Prevalence of psychological effects among the vaccinated and unvaccinated populations against COVID-19 infection.

In the vaccinated populations, there was a positive correlation between psychological distress scores and depression (r_s = 0.118, $p < 0.01$) scores. Moreover, depression scores were positively linked to anxiety (r_s = 0.207, $p < 0.01$), and PTSD (r_s = 0.134, $p < 0.01$) scores. Furthermore, there was a positive relationship between anxiety and PTSD (r_s = 0.117, $p < 0.01$) scores. In the unvaccinated populations, there was a positive correlation between psychological distress scores and fear (r_s = 0.139, $p < 0.01$) scores. Moreover, depression scores were positively linked to anxiety (r_s = 0.306, $p < 0.01$) and insomnia (r_s = 0.762, $p < 0.01$) scores. Furthermore, there was a positive relationship between anxiety scores and stress (r_s = 0.825, $p < 0.01$), PTSD (r_s = 0.212, $p < 0.01$), and insomnia (r_s = 0.644, $p < 0.01$) scores. In addition, stress scores were positively linked to PTSD (r_s = 0.832, $p < 0.01$) and insomnia (r_s = 0.773, $p < 0.01$) scores.

Factors associated with psychological effects

The univariate logistic regression analysis results are presented in Supplementary Table S1. The multivariate logistic regression analysis (Supplementary Table S2) showed that among the COVID-19 vaccine recipients, males were significantly higher risk of symptoms of depression (AOR, 1.80; 95% CI, 1.14–2.14), anxiety (AOR, 1.79; 95% CI, 1.13–2.04), and PTSD (AOR, 1.49; 95% CI, 1.18–1.93) compared to females.

TABLE 3 The prevalence of psychological effects among vaccinated and unvaccinated populations against COVID-19 infection.

Psychological effects	Total (n = 3,013)	Vaccinated population (n = 1,272)	Unvaccinated population (n = 1,741)	p-value
	No. (%)	No. (%)	No. (%)	
Psychological distress symptoms				
Yes	1,359 (45.1)	463 (36.4)	896 (51.5)	0.00
No	1,654 (54.9)	809 (63.6)	845 (48.5)	
Depression symptoms				
Yes	928 (30.8)	268 (21.1)	660 (37.9)	0.00
No	2,085 (69.2)	1,004 (78.9)	1,081 (62.1)	
Anxiety symptoms				
Yes	1,101 (36.5)	319 (25.1)	782 (44.9)	0.00
No	1,912 (63.5)	953 (74.9)	959 (55.1)	
Stress symptoms				
Yes	776 (25.8)	247 (19.4)	529 (30.4)	0.00
No	2,237 (74.2)	1,025 (80.6)	1,212 (69.6)	
Post-traumatic stress disorder symptoms				
Yes	1,040 (34.5)	374 (29.4)	666 (38.3)	0.00
No	1,973 (65.5)	898 (70.6)	1,075 (61.7)	
Insomnia symptoms				
Yes	924 (30.7)	238 (18.7)	686 (39.4)	0.00
No	2,089 (69.3)	1,034 (81.3)	1,055 (60.6)	
Fear symptoms				
Yes	684 (22.7)	205 (16.1)	479 (27.5)	0.00
No	2,329 (77.3)	1,067 (83.9)	1,262 (72.5)	

TABLE 4 Spearman's correlations of psychological effects among vaccinated and unvaccinated populations against COVID-19 infection.

Populations	Psychological effects	1	2	3	4	5	6	7
Vaccinated population	1	1.00						
	2	0.118**	1.00					
	3	0.003	0.207**	1.00				
	4	0.053	0.011	0.005	1.00			
	5	0.002	0.134**	0.117**	0.014	1.00		
	6	−0.011	0.044	0.004	0.018	0.030	1.00	
	7	−0.019	−0.014	0.006	0.004	0.005	0.018	1.00
Unvaccinated population	1	1.00						
	2	0.038	1.00					
	3	0.014	0.306**	1.00				
	4	0.016	0.031	0.825**	1.00			
	5	0.006	0.025	0.212**	0.832**	1.00		
	6	0.003	0.762**	0.644**	0.773**	0.042	1.00	
	7	0.139**	0.003	0.002	0.028	0.024	0.014	1.00

** $p < 0.01$. 1. Psychological distress, 2. Depression, 3. Anxiety, 4. Stress, 5. Post-traumatic stress disorder, 6. Insomnia, 7. Fear.

Vaccinated respondents who lived in nuclear families were significantly higher risk of symptoms of psychological distress (AOR, 1.38; 95% CI, 1.09–1.77), depression (AOR, 1.49; 95% CI, 1.11–1.98), anxiety (AOR, 1.69; 95% CI, 1.21–1.98), and fear (AOR, 1.43; 95% CI, 1.11–1.82) than those who lived in joint families. Except for stress and fear symptoms, married vaccine recipients people were significantly greater risk of all psychological symptoms than those who were divorced, separated, or widowed (e.g., psychological distress: AOR, 1.44; 95% CI, 1.08–1.90; depression: AOR, 2.37; 95% CI, 1.72–3.24). Vaccinated people who used daily social media had significantly more likely to suffer from symptoms of psychological distress (AOR, 1.75; 95% CI, 1.18–2.01), depression (AOR, 1.48; 1.21–1.83), anxiety (AOR, 1.57; 95% CI, 1.16–1.87), and insomnia (AOR, 1.68; 95% CI, 1.02–1.97). Vaccinated respondents who had COVID-19 infected family members, friends, or colleagues were considerably more likely to experience symptoms of psychological distress (AOR, 2.01; 95% CI, 1.33–2.86) and PTSD (AOR, 1.59; 95% CI, 1.10–1.86), but were less likely to experience symptoms of depression (AOR, 0.76; 95% CI, 0.47–0.94) and anxiety (AOR, 0.54; 95% CI, 0.21–0.81). Vaccinated people who lost family members, friends, or colleagues due to the COVID-19 pandemic had significantly higher risk of symptoms of psychological distress (AOR, 1.35; 95% CI, 1.02–1.79), anxiety (AOR, 1.41; 95% CI, 1.11–1.87), and PTSD (AOR, 1.76; 95% CI, 1.24–2.19) than those who did not.

On the other hand, unvaccinated populations who lived in the Dhaka division were significantly associated with an increased risk of depression (AOR, 2.06; 95% CI, 1.40–2.52), anxiety (AOR, 1.86; 95% CI, 1.15–2.47), stress (AOR, 1.92; 95% CI, 1.12–2.88), and insomnia (AOR, 1.88; 95% CI, 1.20–2.94) symptoms than those living in other divisions. Unvaccinated people who had children had significantly higher risk of depression (AOR, 1.66; 95% CI, 1.21–2.18), anxiety (AOR, 1.49; 95% CI, 1.12–1.87), stress (AOR, 1.43; 95% CI, 1.07–1.83), and PTSD (AOR, 1.32; 95% CI, 1.05–1.71) symptoms than those who did not. Except for PTSD and fear symptoms, unvaccinated participants who were unemployed had considerably higher rates of psychological distress (AOR, 1.83; 95% CI, 1.10–2.62), depression (AOR, 1.74; 95% CI, 1.37–2.19), anxiety (AOR, 1.70; 95% CI, 1.12–2.11), stress (AOR, 1.46; 95% CI, 1.08–1.92), and insomnia (AOR, 1.87; 95% CI, 1.20–2.46) symptoms. Unvaccinated people who drank alcohol had significantly greater risk of symptoms of psychological distress (AOR, 2.01; 95% CI, 1.23–2.78), depression (AOR, 1.96; 95% CI, 1.17–2.41), anxiety (AOR, 2.28; 95% CI, 1.27–3.03), and stress (AOR, 1.83; 95% CI, 1.04–2.66) than those who did not. When compared to unvaccinated people who did not have chronic diseases, those with chronic diseases were significantly more likely to experience symptoms of depression (AOR, 1.75; 95% CI, 1.16–2.01), anxiety (AOR, 1.51; 95% CI, 1.07–1.82), and PTSD (AOR, 1.98; 95% CI, 1.12–2.41). Unvaccinated people who were infected with COVID-19 had considerably higher risk of psychological distress (AOR, 1.66; 95% CI, 1.23–2.02), depression (AOR, 1.88; 95% CI, 1.07–2.01), and anxiety (AOR, 1.61; 95% CI, 1.22–1.98) symptoms, but lower risk of fear (AOR, 0.69; 95% CI, 0.41–0.91) symptoms than those who did not. When compared to unvaccinated respondents who had strong social support, those who had poor social support had significantly greater experience of depression (AOR, 1.88; 95% CI, 1.35–2.41), anxiety (AOR, 1.48; 95% CI, 1.01–1.81), and PTSD (AOR, 1.71; 95% CI, 1.20–2.09) symptoms.

Discussion

Bangladesh has been impacted heavily by the COVID-19 pandemic. Every sector has made it an important priority to reduce the impact of COVID-19. This is the first nationwide study that has evaluated the factors associated with psychological effects among vaccinated and unvaccinated populations against COVID-19 infection in Bangladesh. A total of 3,013 general populations were enrolled in our study, with 1,272 (42.2%) being vaccinated and 1,741 (57.8%) being unvaccinated. Our study showed lower prevalence of the symptoms of psychological distress, depression, anxiety, stress, PTSD, insomnia, and fear among vaccinated participants compared with those who were unvaccinated. Psychological distress and PTSD did not vary between groups all other symptoms were considerably lower among vaccinated participants.

This study showed that vaccinated populations had lower prevalence of psychological effects than unvaccinated populations against the COVID-19 outbreak in Bangladesh. Our results are consistent with a study conducted in China among 34,041 general public, which found that the psychological stress level decreased after vaccination (36). Moreover, a nationally representative cohort study of 5,792 adults conducted in the United States found that receiving a COVID-19 vaccination was linked to reduced psychological distress (54), which is also consistent with our findings. Furthermore, a study conducted in Turkey among 304 individuals by Bilge et al. (55) found that the vaccinated individuals had lower scores for depression and anxiety symptoms than unvaccinated individuals, indicating that vaccination may have a positive effect on improving mental health. This finding is also in line with our results. Understanding and addressing the general public's change in psychological effects after receiving the COVID-19 vaccine may assist the government and policymakers in providing comprehensive and accurate information to those who are hesitant or resistant to vaccination, as well as boosting their confidence in the ongoing vaccination campaign. The current study showed many demographic, health, and COVID-19-related factors linked to vaccinated and unvaccinated populations.

Our results showed that male vaccinated populations were significantly higher risk of symptoms of depression, anxiety,

and PTSD compared to females, which is consistent with the findings in other studies (56). This finding is consistent with prior research, which found that male participants displayed a remarkably higher risk for depression symptoms (57). Another study found that male participants showed higher PTSD symptoms than females during the COVID-19 pandemic, which is also consistent with our results (58). But most of the previous Bangladeshi studies found that females were at a higher risk of depression, anxiety, and PTSD symptoms than males during the COVID-19 pandemic period (22, 24). Male participants' higher susceptibility to mental health symptoms during the pandemic may be due to their higher infective rate and more frequent risky behaviors during pandemics (59, 60). However, a study in Bangladesh reported that male participants were more likely to the willingness to pay for the COVID-19 vaccine than females, which is in line with our results (61). Males may have known more about COVID-19 vaccines in Bangladesh than females (62). Therefore, they are more likely to accept the COVID-19 vaccine.

The current study demonstrated that vaccinated people who lived in nuclear families were significantly higher risk of psychological distress, depression, anxiety, and fear symptoms. This finding is consistent with previous Bangladeshi research, which found that participants living in nuclear families reported a higher level of depression and anxiety symptoms during the COVID-19 pandemic (63). A nationwide cross-sectional study among 1,427 Bangladeshi adults found that individuals who lived in nuclear families ($\leq$4 members) were more likely to suffer from psychological problems during the COVID-19 pandemic (24). Since the lockdown was implemented, it's probable that people have been in close contact with their families and have been forced to stay at home for extended periods. As a result, persons who lived in larger families were more likely to have meaningful dialogues and interactions with their family members than those who lived in nuclear households. Therefore, people who lived in nuclear families were more likely to suffer from mental illness. However, recent research in Bangladesh found that residing in a nuclear family was associated with more excellent knowledge about COVID-19 vaccines, which is consistent with our findings (64). Another study indicated that people who lived alone or with a large family (five people) were less likely to say they would be vaccinated for COVID-19 than people who lived in families of two to four people (65). People who grew up in nuclear households were probably more concerned about their health, so they were more accepting of vaccines.

Our findings found that except for stress and fear symptoms, vaccinated populations who were married were significantly associated with a greater risk of all psychological symptoms. A recent national cross-sectional study involving 1,311 community-dwelling individuals in Bangladesh, which found that participants who were married were more likely to be suffering from anxiety symptoms during the COVID-19 pandemic (23). Another study in the same country discovered that marriage increases the risk of mental health problems (66, 67). Both findings are consistent with our findings. It could be why married people have more family responsibilities than unmarried people. However, a cross-sectional online survey among 850 Bangladeshi adults discovered that married individuals were more aware of the vaccine than unmarried individuals, which is similar to our findings (68). Similarly, married people were more likely to declare their intention to obtain COVID-19 immunizations (69). The possible reason behind this might be that married people are worried about their partner. For both, immunization can minimize the chance of illness. Furthermore, knowledge distribution can be enough when they discuss with their partner. Perceived illness risks and attitudes alter depending on relationship status, influencing the decision to use a vaccine.

The present study discovered that vaccinated populations who used daily social media had significantly more likely to suffer from symptoms of psychological distress, depression, anxiety, and insomnia. A Bangladeshi study reported that respondents who used higher social media were associated with depression and anxiety symptoms, which is in line with our findings (70). Similar studies conducted in the same country also reported that those who follow COVID-19-related news on social or other media daily were more likely to have mental health problems (15, 21). Propaganda, falsehoods, conspiracy theories, and other aspects of the pandemic have risen, while social media has emerged as one of the most critical sources of COVID-19-related information. As a result, regularly utilizing social media was a substantial risk factor for psychological problems (71). In August 2020, a survey of 517 Nigerian social media users indicated that 74.5 percent intend to take the COVID-19 vaccination when it is ready (72). Similarly, Piltch-Loeb et al. (73) discovered that those who obtained vaccine information through traditional media rather than social media or both traditional and social media were more willing to accept it. Both studies corroborate our findings. This could be because social media platforms can help educate vaccination doubts, while traditional media outlets should continue to offer data-driven and informed vaccine information to their audiences.

Our findings revealed that vaccinated populations with COVID-19 infected family members, friends, or colleagues had significantly higher risk of symptoms of psychological distress and PTSD but lower risk of depression and anxiety. A study done on Bangladeshi residents demonstrated that participants who reported having family or acquaintances infected with COVID-19 were a protective factor against anxiety symptoms, confirming our findings (21). Furthermore, a cross-sectional study conducted on 3,480 people in Spain reported that those with a close relative infected were associated with more significant symptomatology in PTSD symptoms (74). Family members, acquaintances, or colleagues of COVID-19 patients may likely be concerned about becoming infected, quarantined,

and feeling ostracized, all of which may worsen psychological problems. However, a large sample study in Bangladesh showed that those with family members diagnosed with COVID-19 were more likely to accept the COVID-19 vaccine, which is in line with our findings (75). Their decision was probably affected by social responsibility and positive experiences with vaccination and immunization programs.

The current study discovered that people who were vaccinated against COVID-19 and lost family members, friends, or coworkers were significantly higher risk of psychological distress, anxiety, and PTSD symptoms. In a study conducted in Bangladesh by Zubayer et al. (21), having relatives or acquaintances who died from COVID-19 was found to be a stronger predictor of anxiety symptoms, which is in line with our findings. Similarly, another study involving 10,754 people from 31 Iranian districts revealed that losing a loved one to COVID-19 causes psychological issues (76). This conclusion is also consistent with the framework proposed by Ghaleb et al. (66), which found that having a friend who died of COVID-19 was related to greater psychological distress levels. It could be due to people's concern for the wellbeing of family members, friends, or coworkers and their safety. However, a cross-sectional study of 883 people in Pakistan reported that those who had lost family members, friends, or coworkers significantly impacted their willingness to accept the COVID-19 vaccine (77). A probable explanation is that people whose relatives have died from COVID-19 may have learned more about the virus and its consequences on human health. As a result, they may desire to protect themselves by getting COVID-19 vaccines.

The present study found that unvaccinated populations who lived in the Dhaka division were significantly associated with an increased risk of depression, anxiety, stress, and insomnia symptoms. A study conducted among 10,609 individuals in the COVID-19 outbreak in Bangladesh showed that respondents who lived in Dhaka found higher experienced symptoms of depression, anxiety, and stress (78). According to two similar studies conducted in the same country, respondents who lived in the Dhaka division were significantly more likely to be depression, anxiety, and insomnia symptoms (22, 79). The initial findings supported our findings. This could be a contributing factor because the Dhaka division has the most significant population and handles most COVID-19 cases in Bangladesh (16). Therefore, during this or future pandemics, residents from the Dhaka division should receive special attention and care from the relevant authorities. In addition, Dhaka, the capital city of Bangladesh, is home to an estimated four million slum inhabitants (80). They are a socioeconomically deprived group with little understanding of COVID-19 and weak prophylactic actions against virus infection (17). This may contribute to their aversion to immunization. A comparable survey in the Mumbai slum in India reported a 20% unacceptance of COVID-19 vaccines among slum inhabitants (81).

Our findings showed that unvaccinated populations who had children had a significantly greater risk of depression, anxiety, stress, and PTSD symptoms. A recent study in Bangladesh found that respondents who had children during the COVID-19 pandemic had more depression and stress symptoms, which is confirmed by our findings (82). Similarly, it is also consistent with earlier studies conducted among the 1,041 general population of the Republic of Ireland, Karatzias et al. (58) revealed that people with children had a higher risk of PTSD symptoms. Similar findings are reported in a previous study (66). This link could be explained by concern about spreading the virus to family members. However, this outcome is consistent with other investigations, which found that vaccine hesitancy was higher among those who had children at home (83). It's possible that participants were worried about vaccine side effects on themselves or their children.

Unsurprisingly, the current study found that unvaccinated populations who were unemployed had higher rates of psychological distress, depression, anxiety, stress, and insomnia symptoms. This conclusion is backed by research of 974 healthy persons done in Bangladesh, which found that unemployed people had higher rates of depression, anxiety, and stress symptoms during the COVID-19 pandemic (84). This finding is also supported by a nationwide study conducted in the same country, which reported that unemployed respondents experienced high-stress levels during the COVID-19 pandemic (24). Similarly, an online cross-sectional survey among 672 Bangladeshi people during the COVID-19 pandemic showed that unemployed respondents were more likely to be had poor mental health (85). Unemployment is likely linked to low self-esteem, social isolation, and low income, which can contribute to psychological problems. However, a nationwide investigation in Bangladesh involving 1,134 adults aged 18 and over found that unemployment was associated with a higher risk of COVID-19 vaccine discomfort, which is consistent with our findings (86). On the other hand, other research found that unemployed persons were more inclined to receive the COVID-19 vaccination since, in some locations, unemployed people may seek to return to employment, which can only happen after immunization (83, 87).

The current study revealed that unvaccinated populations who drank alcohol had significantly higher risk of psychological distress, depression, anxiety, and stress symptoms. This conclusion is supported by several Bangladeshi COVID-19-related studies, which found that those who drank alcohol had a substantially increased risk of developing psychological problems (22, 88). Research shows that people who drink alcohol are more likely to develop mental health problems. People with severe mental illness are also more prone to have alcohol issues. This could be because they 'self-medicate' or drink to cope with unpleasant feelings or symptoms (89). However, a nationwide study of 23,142 people in Japan found that respondents who consumed alcohol were significantly associated

with COVID-19 vaccine hesitancy, which is similar to our results (90). Furthermore, a recent study demonstrated that those who drank alcohol daily had a lower level of vaccine literacy (91). It might be possible because there are misleading rumors and misconceptions about immunizations. To boost vaccine acceptance among the general population, our findings suggest that false rumors and misconceptions concerning COVID-19 immunizations should be eliminated, and people should be educated on the actual scientific facts.

The present study demonstrated that unvaccinated populations with chronic diseases were significantly higher risk of symptoms of depression, anxiety, and PTSD. Our findings supported Mamun et al. (22) from a population-based nationwide study of 10,067 individuals in Bangladesh, which indicated that respondents with chronic diseases were more experienced with depression symptoms during the COVID-19 pandemic. Another study in the same country also reported that participants with chronic diseases had a higher chance of depression and anxiety symptoms during the COVID-19 pandemic (79). During the COVID-19 pandemic, a similar study undertaken in Ireland found that people with chronic conditions had a higher risk of depression, anxiety, and PTSD symptoms (58). Any psychological containment plan should cater to these individuals and provide them with tailored tools and tactics to help them psychologically cope with the COVID-19 crisis. However, in a study of 3,646 Bangladeshi adults aged 18 years or above, Abedin et al. (92) discovered that those with chronic conditions were more likely to be vaccine-hesitant, which is also supported by our findings. Low vaccine understanding, concerns about effectiveness, potential adverse effects, and a lack of trust in vaccines are possible reasons for vaccine refusal. Our findings indicated that people should be health-conscious and vaccinated as soon as possible.

Our findings discovered that unvaccinated populations who were infected with COVID-19 were more likely to suffer from psychological distress, depression, and anxiety symptoms but lower risk of fear symptoms. Consistent with our findings, a recent study conducted in Bangladesh by Abir et al. (93) discovered that those who had been tested for COVID-19 had a higher risk of psychological distress symptoms. Another study in the same country also found the same results (94). A study involving 56,679 adults aged 18 and older from all 34 province-level locations in China found that people with confirmed or suspected COVID-19 had a significantly higher risk of depression and anxiety symptoms, which also matched our findings (57). Moreover, Wang and colleagues (95) observed similar findings in a comprehensive evaluation of 68 research, including 288,830 participants from 19 countries. It's probable that they were worried about the consequences of getting infected with such a dangerous new virus and that they were bored, isolated, and frustrated while in quarantine. However, a study in Bangladesh indicated that those who had previously been infected with COVID-19 were less willing to get vaccinated than those who had not, which is supported by our results (92). This implies a lack of health communication, as there is a widespread misconception that a person gains immunity after recovering from a COVID-19 infection, which may have contributed to this group's unwillingness. The findings of this study point to the necessity for increased public education and risk awareness to take preventive measures to improve COVID-19 pandemic control.

Undoubtedly, unvaccinated populations with poor social support had significantly more significant experience of depression, anxiety, and PTSD symptoms. Our results are consistent with those of Zhang et al. (96), who discovered that people who had less social support had a higher risk of depression and anxiety symptoms. A similar study conducted in China also demonstrated that respondents who had lower social support were more likely to be a chance of depression and PTSD symptoms (56). However, a study conducted in the Philippines found that having more social support was associated with a good intention to obtain the human papillomavirus (HPV) vaccine, which is in line with our findings (97). Social support is vital for dealing with psychological problems and may also be associated with vaccine antibody responses (53, 98). Therefore, the results of this study may guide authorities and policymakers on how to address psychological difficulties and reduce resistance to the COVID-19 vaccine by enlisting the help of family, friends, and coworkers.

Suggestions

Several actions may and should be taken right now to mitigate the psychological effects of the COVID-19 pandemic on the general public. First, COVID-19 vaccination uptake can be increased after the findings highlighted in this study are addressed, and the immunizations' long-term beneficial and psychological effects are communicated to the general public. To ensure that COVID-19 immunizations reach as many people as possible, the government, public health professionals, and advocates must be prepared to handle vaccine anxiety and boost vaccine education among potential recipients. Evidence-based educational and policy approaches are needed to address these concerns and support COVID-19 vaccination programs. Second, according to the current findings, risky persons should receive special care due to their vulnerability to significant psychological problems. Third, cognitive behavior therapy (CBT) is the most evidence-based treatment, notably internet-based CBT, which can be helpful for mental health interventions during the pandemic. Fourth, the government, non-governmental organizations (NGOs), voluntary organizations, and youth-led projects should offer free tele-counseling and video-counseling, develop psychological support programs for various institutions and workplaces, and develop guidelines for these support services to assist people

with mental health problems. Fifth, based on our findings, Bangladesh's general population needs immediate community-based psychosocial support and mental health awareness. Sixth, providing clear communication with regular and transparent updates about the COVID-19 outbreak, advising people to activate their social networks to improve connection with others and maintain their normal daily routine when applicable, and ensuring basic supplies could all help to alleviate mental health problems.

Strengths and limitations

Some of the study's advantages are as follows: first, this is the first nationwide study in Bangladesh that has evaluated the psychological effects and associated factors among vaccinated and unvaccinated general populations against COVID-19 infection. Second, this groundbreaking study revealed that people's COVID-19 immunization had a significant positive impact on their mental health. Third, it was possible to draw meaningful conclusions from this study because it included all of Bangladesh's divisions and occupations. Fourth, this research will add to our understanding of COVID-19 vaccination and mental health, as well as assist governments and policymakers in developing an effective vaccine campaign to achieve vaccination coverage and herd immunity among various occupational populations during the COVID-19 pandemic. Finally, our findings could be useful in policymaking, identifying high-risk communities, and developing frameworks for population-specific psychological crisis management.

Our research is not without limitations. First, psychological effects were assessed using a self-report technique and an online survey. Only people who have a smartphone and use some SNS/apps participated in the survey. To acquire a more thorough understanding of the situation, future studies should involve clinical interviews or qualitative studies. Second, only the people who had the two doses of vaccine were included in the survey, and those who had one dose of vaccine were excluded. Future studies should examine whether there were comparable differences between those who received a single dose or booster dose of the vaccination and those who did not. Third, because it was a cross-sectional study, there was no way to prove causation. Therefore, this study recommends that longitudinal studies be conducted to overcome this limitation. Fourth, convenient and snowball sampling was used in this study, resulting in selection biases and poor representativeness. Fifth, it is impossible to assess the participation rate because it is unknown how many subjects received the survey link. Sixth, pre-existing co-morbidity (males, Dhaka residents, and unemployed individuals) may also have the effect on mental health following vaccination, which is considered a stressful event. Last but not least, in this study, factors such as which developer's vaccination you received and whether or not you received any vaccine beyond the age of 18 were not considered.

Conclusion

This study recommends immunizing unvaccinated populations as soon as possible to prevent infection and boost mental health. Males, nuclear family members, married people, daily social media users, people who had COVID-19 infected family members, friends, or colleagues, and people who had lost family members, friends, or colleagues due to the COVID-19 pandemic were associated with higher mental health problems among vaccine recipients. In contrast, participants living in the Dhaka division, having children, unemployed, drinking alcohol, having chronic diseases, being infected with COVID-19, and having poor social support were associated with higher mental health problems among those who did not receive the vaccine. Vulnerable people needed special care, health-related education, and psychological assistance.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Department of Psychology, Jagannath University, Dhaka, Bangladesh, and the Ethics Committee of the First Affiliated Hospital, Zhejiang University School of Medicine, Hangzhou, China. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MDA: conceptualization, methodology, formal analysis, and writing-original draft. MDA, MJA, AI, MM-UH, and OR: data collection. MDA and YX: writing—review and editing. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.916160/full#supplementary-material

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Anticipatory threat responses mediate the relationship between mindfulness and anxiety: A cross-sectional study

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Increasing research has shown that mindfulness-based interventions can effectively alleviate anxiety; however, the underlying neural mechanism has not yet been elucidated. Recent studies suggest that abnormal and excessive anticipatory responses to unpredictable threats play an important role in anxiety symptoms. Mindfulness refers to the non-judgmental awareness of the present moment's real experience, which is antithetical to the future-oriented thinking processes involved in anxiety-oriented cognition and its corresponding emotion regulation tactics. Thus, mitigating anticipatory threat responses may be a potential mechanism by which mindfulness alleviates anxiety. This study aimed to detect the possible mediating effects of anticipatory threat responses on the relationship between mindfulness and anxiety. A total of 35 trait-anxious (TA) individuals and 36 low-anxious (LA) individuals were recruited to participate in the predictable and unpredictable threat test. Self-reported intolerance of uncertainty (IU) and electroencephalographic responses to uncertainty were recorded. TA individuals reported more IU and less mindfulness, and exhibited significantly higher late positive potential (LPP) and longer reaction time (RT) than LA individuals in the unpredictable negative threat condition. In addition, there were significant mediating effects of the LPP amplitude and RT in the uncertain threats on the relationship between mindfulness and anxiety. The data from this study verified that mitigating anticipatory threat responses (including self-reported IU, behavioral RT, and LPP amplitude) might be the potential mechanism by which mindfulness alleviates anxiety. These findings may have practical implications for the development and optimization of mindfulness treatments for anxiety.

KEYWORDS

anxiety, mindfulness, anticipatory threaten responses, intolerance of uncertainty, LPP

Introduction

Anxiety is a salient feeling of worry, nervousness, or unease when facing a threatening situation. People with pathological anxiety experience hypervigilance and increased behavioral responsivity in the absence of rationally fearful stimuli (1). A lifetime prevalence estimate of 28.8% places anxiety disorders as the most common class of mental disorders, causing serious damage to patients' social functioning (2). Furthermore, the COVID-19 pandemic has led to an 11.2% increase (95% uncertainty interval: 5.3–17.3) in cases of anxiety disorders in China in 2020 (3, 4), which heavily burdens both families and society.

Mindfulness-based interventions (MBIs) are a promising category of anxiety treatment. Mindfulness is the basic attentional stance underlying various Buddhist traditions, such as Theravada, Vajrayana and Mahayana (Zen), and has been called "the heart" (or "dharma" in Sansfrit) of Buddhist meditation, which was historically developed as a method to suspend personal suffering (5). Since it spread to the West, it has been increasingly applied in clinical settings. Mindfulness is commonly defined as the perception and acceptance of constantly changing experiences (6), which may include thoughts, emotions, somatic sensations, and responses to the external stimuli (7, 8). Evidence of its validity in alleviating anxiety comes from studies demonstrating negative relationships between mindfulness and anxiety (9, 10), intervention research (11–14), and meta-analysis (15–17). Over the past several decades, MBIs have been increasingly utilized among groups of relatively healthy individuals to promote wellbeing, as well as in a wide variety of clinical disorders, as a complement to cognitive or behavioral techniques to relieve mental distress (18, 19). The most common and well-studied MBIs are mindfulness-based cognitive therapy (MBCT) and mindfulness-based stress reduction (MBSR). MBSR is a manualized treatment program widely used to reduce psychological morbidity associated with chronic illnesses and treat emotional and behavioral disorders (6). MBCT is similar to and involves MBSR but emphasizes the ability to self-manage, control, and improve (17). Although empirical research on the effectiveness of mindfulness is increasing, the mechanisms through which mindfulness improves anxiety have rarely been investigated. One potential mechanism is an anticipatory response to uncertain threats (20).

Immoderate reactions to uncertain stimuli have been regarded as an intolerance of uncertainty (IU) (20). People with high IU are inclined to consider ambiguity a threat and are prone to overestimate the likelihood of an uncertain event and the cost of responding, thus resulting in maladaptive behaviors such as vigilance (i.e., paying more early phasic and sustained attention to uncertain target cueing) (21) and avoidance, which aims to decrease uncertainty (22). Recent perspectives consider anxiety to be a future-oriented emotional state; abnormal and excessive anticipatory responses under unpredictable threats explain the unique variance in anxiety psychopathology that contributes to stress and anxious behaviors (20, 23). Consistent with this perspective, a meta-analysis showed that IU is strongly associated with a range of symptoms in disorders, such as obsessive-compulsive disorder, panic disorder, social anxiety disorder, and agoraphobia, thus validating IU's trans-diagnostic importance (24).

Unlike the excessive anticipation reaction to potential future threats experienced in a state of anxiety, mindfulness refers to the non-judgmental awareness of the present moment's real experience, which is contrary to the future-oriented thinking involved in anxiety-driven cognition and its relevant emotion regulation strategies (7, 25). The anxiety-attenuating effects of MBIs have already been observed in the anticipatory phase for negative emotions, cortisol, and the autonomic nervous system (26), especially in the parasympathetic nervous system (27). Kim's research on panic disorders claimed that there was a significant correlation between the reduction in IU and relief of panic symptoms after MBCT (12). In line with this research, another cross-sectional study indicated that the benefits of mindfulness on anxiety symptoms are mediated by self-reported IU. However, this mediating effect was not confirmed in physiological responses (i.e., the startle reflex) to uncertain threats (20). One possible interpretation of this finding is that the IU questionnaire measured a higher-order cognitive process response to uncertainty while the startle reflex measured a lower-order defensive response to uncertainty.

Recent electrophysiological (EEG) studies have focused on the modulation of anxiety over threat anticipation by the intensity of uncertainty and found that, compared with certain cues, uncertain aversive cues elicit significantly larger stimulus-preceding negativity (SPN), P2 (a positive posterior deflection peaking at 200–250 ms), and late positive potential (LPP) (21, 28). The LPP is a centroparietal slow wave that seems to be modulated by higher-level cognitive processing (29) and has been demonstrated to be sensitive to stimulus predictability (30). With respect to uncertainty processing, studies have reported increased LPP amplitude for uncertain aversive cues compared with certain safe cues in threat-of-shock designs (21, 31). According to Grupe's "uncertainty and anticipation model of anxiety" (UAMA) theory (23), the overestimation of threat costs and probabilities causes exaggerated emotional and behavioral reactivity in anxious individuals. Thus, we chose LPP as an indicator of sustained cognitive processing in our research, which explores the potential mediating effects of uncertain threat responses on the association between mindfulness and anxiety and further investigates whether the relationships would vary according to the degree of threat exhibited by the stimuli (32).

Ongoing research has shown that the neural correlates of trait anxiety can predict pathological anxiety-driven behaviors (32). Thus, the present study focused on highly anxious

individuals to explore the underlying mechanisms through which mindfulness alleviates anxiety. It was hypothesized that (1) both trait-anxious (TA) individuals and low-anxious (LA) individuals would express excessive anticipatory responses (including self-reported IU, behavioral reaction time (RT) and EEG responses) under conditions of threat uncertainty, and that the TA group's response would be more intense; (2) mindfulness would be negatively correlated with anxiety and IU; and (3) reactions to uncertainty might be the possible mechanism by which mindfulness alleviates anxiety.

Materials and methods

Participants

To recruit individuals with different levels of anxiety, recruitment advertisements were posted at the Army Medical University and three affiliated hospitals. Volunteers who scanned the quick response (QR) codes on the advertisements to sign up for the study were asked to complete the screening questionnaires ($n = 191$). The presence of psychiatric and neurological diseases was assessed through this screening questionnaires. We applied the following inclusion criteria: (1) aged 18–45 years, (2) right-handed individuals, (3) no history of neurological or psychiatric diagnosis, and (4) normal visual acuity or corrected visual acuity. In total, 162 subjects completed all questionnaire items and met all inclusion criteria. Based on their scores on the Trait Anxiety Inventory (TAI) in the State-Trait Anxiety Inventory (33), participants who scored 44 and above were classified as TA individuals while those with a score of 34 and below were classified as LA individuals (34). Thus, we invited 35 TA individuals and 36 LA individuals to participate in further EEG research. The intentions and project procedure of this study were then provided to qualified participants, and their written informed consent was obtained. This study was conducted in accordance with the Declaration of Helsinki. The regional ethics committee of the Army Medical University approved this consent procedure and the study protocol (reference number: 2020-019-02). Participants were paid 50 RMB after they finished this study.

Figure 1 shows the participants' flowchart. A total of 71 participants (TA group = 35, LA group = 36) were eligible to participate in the EEG experiments. Eight subjects were excluded because of excessive EEG artifacts. The final sample comprised 63 participants (TA group = 32, LA group = 31). G*Power 3.1.9.7. was used to determine the sample size. Based on the input parameters specifying a medium effect size of $f = 0.25$, $\alpha = 0.05$, $1\text{-}\beta = 0.95$, number of groups = 2, and number of measurements = 4, we obtained a total sample size of $N = 36$. Thus, the sample size of our study ($n = 63$) was sufficient for statistical analysis.

Task design

Participants completed self-report questionnaires and EEG assessments under predictable and unpredictable conditions. The EEG recordings were conducted in a sound-attenuated room. The task was a modified version of a published threat test (35) that included four conditions: (1) predictable positive events (PP), (2) predictable negative events (PN), (3) unpredictable positive events (UP), and (4) unpredictable negative events (UN). Each condition contained 80 trials, with each trial consisting of a 300-ms fixation point presented at the center of the computer screen, followed by a 600-ms cue (i.e., "positive" or "negative"), after which a sequence of numbers would appear. Participants were told that a pleasant or aversive image (their valence was in accordance with the cues) would be shown on the screen after the sequence of numbers. During predictable conditions, the numbers would count down from any number between 10 and 6 to 1, at which point an image would appear. Under unpredictable conditions, the sequence of numbers would appear randomly, and pleasant or aversive images would be presented at any time. Pictures were presented for 1,500 ms and subjects were required to determine whether the scenes in the image occurred indoors (press "F" on the keyboard) or outdoors (press "J" on the keyboard). The image disappeared after the keystroke. After a 100-ms blank screen, feedback (correct or false) for participants' responses appeared (see Figure 2). The RT of the images was collected only for the correct response and then averaged for each condition.

The task consisted of two predictable runs and two unpredictable runs with a counterbalanced sequence. Each run consisted of 40 positive and 40 negative trials, and the order of the images was randomized. At the end of each run, a mandatory 30-s rest was provided. Before the formal experiment began, eight practice trials were performed to familiarize the participants with the paradigm. To ensure that all participants received the same information, instructions on the experimental procedures were standardized and displayed on a computer screen before the practice stage. The same researcher answered all questions throughout the study process.

Materials

A total of 320 images were selected from the native Chinese Affective Picture System (CAPS) (36). A 9-point scale ranging from 1 (negative/calm) to 9 (positive/arousal) was used to evaluate each picture's valence and arousal degree. In the present study, the mean valence and arousal ratings of the selected 160 positive images were 6.71 ± 0.37 and 5.76 ± 0.58, respectively. The selected 160 negative images had a mean valence and arousal rating of 2.84 ± 0.83 and 5.01 ± 0.55, respectively. The valence and arousal ratings of the 160 pictures following the

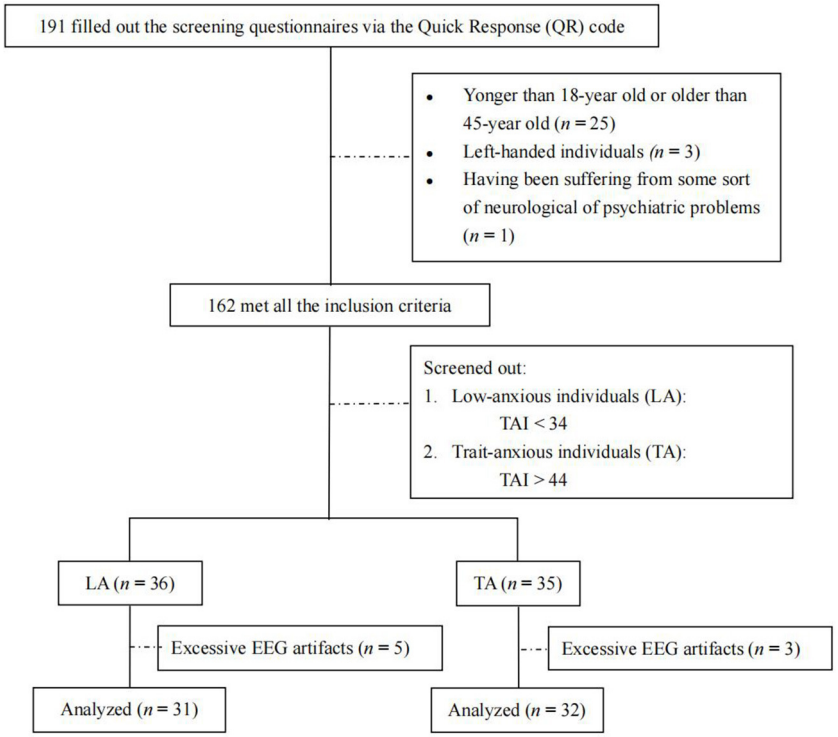

FIGURE 1
Flow of participants.

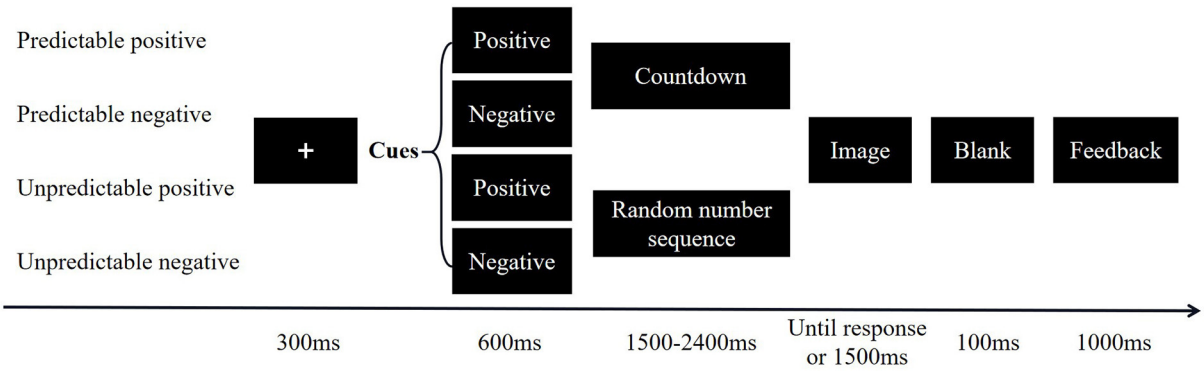

FIGURE 2
Schematic of experimental procedure.

predictable cue and the 160 pictures following the unpredictable cue were not significantly different [valence rating: $t(318,1) = -1.5$, $p = 0.13$; arousal rating: $t(318,1) = -0.98$, $p = 0.33$]. Both predictable and unpredictable trials contained half of the positive and half of the negative images. Differences in the valence and arousal ratings between the 80 negative and 80 positive pictures for predictable trials [valence rating: $t(158,1) = 33.43$, $p < 0.01$; arousal rating: $t(158,1) = 11.86$, $p < 0.01$] were similar to the corresponding differences in unpredictable trials [valence rating: $t(158,1) = 66.98$, $p < 0.01$; arousal rating: $t(158,1) = 5.91$, $p < 0.01$].

Questionnaires

Hospital anxiety and depression scale (HADS)

The HADS was constructed using the 7-item anxiety subscale and the 7-item depression subscale. A 4-point Likert

scale ranging from 0 (not at all) to 3 (almost all the time) was used to evaluate participants' emotional states in the preceding month. The total scores ranged from 0 to 21, with a critical value of 9 for each subscale (37). The internal consistency coefficients of the anxiety subscale and the depression subscale for our sample were 0.90 and 0.89, respectively.

Trait anxiety inventory (TAI)

The 20-item TAI was administered to measure participants' general feelings of anxiety using a 4-point Likert scale (1 = barely, 4 = almost always). The total scores range from 20 to 80, with higher scores indicating greater trait anxiety (33). The Cronbach's alpha for our sample was 0.95.

Intolerance of uncertainty scale (IUS)

The IUS includes 11 items that assess how people react to uncertain situations in their lives. Participants rated the items on a 5-point Likert scale ranging from 1= "not at all characteristic of me" to 5= "entirely characteristic of me". The total scores ranged from 11 to 55, with higher scores indicating less tolerance to uncertainty (38). The Cronbach's alpha for our sample was 0.96.

Five facet mindfulness questionnaire (FFMQ)

The 20-item FFMQ was used to measure five facets of mindfulness: observing, describing, acting with awareness, non-judging to inner experience, and non-reacting to inner experience. Participants rated the items on a 5-point Likert scale (1 = never or very rarely true, 5 = very often or always true) (39). The Cronbach's alpha for our sample was 0.84.

EEG recording and data reduction

Continuous EEG data were collected using a 64 channel NuAmp acquisition system (Neuroscan Inc.) according to the international 10–20 system, with a reference at Cz and the ground placed between Fz and Fpz. Horizontal and vertical EEG activity was recorded from positions next to the outer rims of each eye and from above and below the right eye, respectively. The sampling rate was 1,000 Hz, and the impedances of all electrodes were below 5kΩ.

Offline, a digital average mastoid reference, (M1+M2)/2, was performed. The raw EEG data were bandpass filtered from 0.01 Hz to 30 Hz and manually scored for muscle and eye movement artifacts. They were segmented from 100 ms before cue onset to 2,000 ms afterward, referred to as baseline −100 to 0 ms before cue onset. Six electrodes–CP3, CPz, CP4, P3, Pz, and P4–were selected for further analysis, since the LPP in existing research was detected mostly in the centro-parietal region of the scalp (21). The inspection of the EEG data revealed a late positive component (with an onset of approximately 400 ms and an offset of approximately 1,100 ms) over parietal occipital sites. The mean amplitude of the LPP was extracted for further analysis (see Supplementary Table 1).

Data analyses

Data analyses were performed using SPSS 19.0 and AMOS 20.0. The Shapiro-Wilk normality test was used to assess data or variable distribution. Age, HADS_A, TAI, and IUS did not show a normal distribution; therefore, comparisons were made by the Mann-Whitney *U* test. The differences in demographic variables (except Age) and FFMQ between TA group and LA group were analyzed by independent samples *t-tests* and chi-square tests. After splitting the data by group, a 2 (Groups: TA, LA) × 4 (Conditions: PP, UP, PN, and UN) repeated-measures analysis of variance (rmANOVA) was applied to examine the discrepancies in behavioral RT and LPP amplitude with respect to the four stimuli conditions for the TA and LA groups. Greenhouse–Geisser correction was applied to correct all ANOVA results. The Sidak correction was used to correct alpha for multiple comparisons. The Spearman rank-order correlation was used to calculate the relationships between variables. The *cocor* was used to conduct statistical comparisons between correlations (40). The mediation hypothesis was tested with structural equation modeling (SEM). Indices including CMIN/DF (a value between 1 and 3 indicates acceptable fit between the hypothetical model and the sample data), adjusted goodness-of-fit index (AGFI, a value >0.90 indicates acceptable model fit) (41), and root-mean-square error of approximation (RMSEA, a value between 0.05 and 0.08 reflects reasonable model fit) (42) were calculated to assess the overall model fit.

Results

Self-report measures

According to the parametric and non-parametric test results, group differences in the demographic variables were not significant (see Table 1). Table 2 shows the means and standard deviations for all self-reported variables for the TA and LA groups. According to the independent samples *t*-test and Mann-Whitney U test, the grouping effects for all self-reported variables were significant, with lower scores for FFMQ and subscales (except for the observing subscale), and higher scores for HADS-A, TAI, and IUS in the TA group. The results indicated that the participants in the TA group were more intolerant of uncertainty, tended to feel more stress, and had less mindfulness than emotionally healthy participants.

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TABLE 1 Between-group differences regarding demographic data.

	LA, $n = 31$		TA, $n = 32$		Total, $n = 63$	
	Mean	***SD***	**Mean**	***SD***	**Mean**	***SD***
Age	21.45	3.54	22.63	6.66	22.05	5.35
	n	**%**	***n***	**%**	***n***	**%**
Gender						
Male	24	77.42	27	84.38	51	80.95
Female	7	22.58	5	15.62	12	19.05
Educational background						
Junior high school diploma	0	0	3	9	3	4.76
Senior high school diploma	4	12.90	5	16	9	14.29
College degree	24	77.42	24	75	48	76.19
Graduate degree	3	0	0	0	3	4.76
Marital status						
Single	30	96.77	28	87.50	58	92.06
Married	1	3.23	4	12.50	5	7.94

Using Mann-Whitney U tests and Chi-square tests, between-group differences in the demographic variables were not statistically significant. LA, Low-anxious individuals; TA, Trait-anxious individuals.

TABLE 2 Scores on self-report scales for the LA ($n = 31$) and TA ($n = 32$).

	LA *M (SD)*	TA *M (SD)*	*p*
HADS-A	10.19 (1.92)	17.47 (3.11)	< 0.001
TAI	29.26 (3.39)	54.94 (5.91)	< 0.001
IUS	21.94 (8.70)	40.63 (6.98)	< 0.001
FFMQ	71.61 (7.32)	56.91 (9.23)	< 0.001
FFMQ_Observing	13.77 (3.30)	12.94 (2.75)	0.278
FFMQ_Describing	15.10 (3.03)	11.09 (2.75)	< 0.001
FFMQ_Acting with awareness	16.16 (2.42)	10.78 (3.77)	< 0.001
FFMQ_Non-judging to inner experience	13.35 (2.97)	11.00 (2.55)	0.002
FFMQ_Non-reacting to inner experience	13.35 (2.90)	11.09 (3.31)	0.005

LA, Low-anxious individuals; TA, Trait-anxious individuals; M, Means; SD, Standard Deviations; HADS-A, Anxiety subscale of Hospital Anxiety and Depression Scale; TAI, Trait Anxiety Inventory; FFMQ, Five Facet Mindfulness Questionnaire; IUS, Intolerance of Uncertainty Scale.

RT to the images

Table 3 presents the results of the rmANOVA after splitting the RT to analyze the TA and LA groups across the four conditions. Although no significant group × condition interaction was found, there was a significant main effect of the condition. For all participants, the mean RT during the UN condition was significantly longer than those during the other three conditions, and the mean RT during PN was significantly longer than that during PP. The rmANOVA for RT also revealed a significant main effect of the group. The mean RT of TA group was significantly longer than that of the LA group, particularly with UN stimuli. Based on the results, we found that participants waited longer to press keys on uncertain and negative stimuli, especially in the TA group.

LPP

Table 4 presents the significant main effect of condition and group × condition interactions at the three occipital electrodes (i.e., CP3, PZ, and P4). Follow-up planned comparisons indicated that for the TA group, the amplitude of LPP during trials signaling unpredictable negative stimuli was greater than that of LPP during trials signaling certain positive stimuli ($p < 0.009$). Although there were upward trends from certain conditions to unpredictable conditions and from positive to negative stimuli on the amplitude of LPP for the LA group, the changes were not statistically significant. In addition, within the unpredictable negative condition, the TA group demonstrated significantly higher LPP than the LA group ($p = 0.02$, CP4 and 0.01, P4), whereas in the other three conditions (PP, UP, PN), the amplitude of LPP to cues did not differ significantly between groups (see Table 4, Figure 3).

Mediation model of anticipatory response to uncertain threats on mindfulness improving anxiety

The intercorrelations between all variables are summarized in Table 5. IUS scores, RT, and LPP amplitude to uncertain threats were all significantly related to scores on measures of

TABLE 3 Means (*M*), Standard Deviations (*SD*) and the results of rmANOVA for RT.

	N	PP *M(SD)*	UP *M(SD)*	PN *M(SD)*	UN *M(SD)*	Within subject effect *F(df)*	Interaction Effect *F(df)*	Between subject effect *F(df)*
LA	31	646.13 (14.38)[abc]	660.90 (14.46)[ab]	673.68 (15.31)[ab]	711.11 (16.63)[a]	54.51***	0.44	10.52***
						(2.49, 151.81)	(2.49, 151.81)	(1, 61)
TA	32	712.04 (14.16)[bc]	718.36 (14.24)[b]	741.07 (15.07)[b]	780.53 (15.95)			

LA, Low-anxious individuals; TA, Trait-anxious individuals; UP, Unpredictable positive events; PP, Predictable positive events; PN, Predictable negative events; UN, Unpredictable negative events; RT, Reaction time; M, Means; SD, Standard Deviations.
***$p < 0.001$.
[a]$p < 0.05$ for rmANOVA post hoc test for LA – TA.
[b]$p < 0.0087$ (Sidak correction) for rmANOVA post hoc test for UP/PP/PN – UN.
[c]$p < 0.0087$ (Sidak correction) for rmANOVA post hoc test for PP – PN.

TABLE 4 Results of the rmANOVA on two groups and four conditions for LPP.

		PP *M (SD)*	UP *M (SD)*	PN *M (SD)*	UN *M (SD)*	Interaction effect *F(df)*
CP3	LA	0.22 (0.35)	0.35 (0.39)	0.38 (0.44)	0.26 (0.40)	**2.93***
						(2.87, 175.29)
	TA	−0.21 (0.34)[a]	0.15 (0.38)	0.59 (0.43)	1.10 (0.40)	
CPZ	LA	0.49 (0.38)	0.45 (0.39)	0.66 (0.46)	0.54 (0.47)	2.22
						(2.86, 174.67)
	TA	0.57 (0.37)[a]	0.78 (0.39)	0.95 (0.46)	1.75 (0.46)	
CP4	LA	0.37 (0.35)	0.32 (0.39)	0.55 (0.45)	0.33 (0.45)	2.79
						(2.72, 165.94)
	TA	0.60 (0.34)[a]	0.82 (0.38)	1.01 (0.44)	1.91 (0.45)[b]	
P3	LA	0.14 (0.33)	0.28 (0.41)	0.37 (0.40)	0.32 (0.35)	2.26
						(2.67, 162.99)
	TA	0.25 (0.32)[a]	0.21 (0.40)	0.47 (0.40)	1.26 (0.34)	
PZ	LA	0.66 (0.34)	0.66 (0.39)	0.72 (0.43)	0.77 (0.46)	**3.57***
						(2.75, 167.47)
	TA	0.44 (0.34)[a]	0.86 (0.38)	1.09 (0.42)	2.04 (0.45)	
P4	LA	0.18 (0.33)	0.31 (0.43)	0.43 (0.42)	0.31 (0.43)	**3.23***
						(2.71, 165.25)
	TA	0.44 (0.33)[a]	0.85 (0.42)	0.97 (0.41)	2.03 (0.42)[b]	

LPP, late positive potential; LA, Low-anxious individuals; TA, Trait-anxious individuals; UP, Unpredictable positive events; PP, Predictable positive events; PN, Predictable negative events; UN, Unpredictable negative events; CP3; CPz; CP4; P3; Pz and P4, electrodes on the centro-parietal region of the scalp.
*$p < 0.05$.
[a]$p < 0.0087$ (Sidak correction) for rmANOVA post hoc test for PP – UN.
[b]$p < 0.05$ for rmANOVA post hoc test for LA-TA. The bold values indicates statistically significant *p*-values.

anxiety symptoms and were inversely related to FFMQ scores. These results support the supposed correlations and allow for further mediation analyses. Self-reported IUS was significantly associated with RT to the images in both anxiety groups. No significant relationship between IUS scores and LPP amplitude was found.

The SEM results demonstrated that the overall model yielded a satisfactory fit, CMIN/DF = 1.68, RMSEA<0.08, and AGFI = 0.99. All specific indirect effects on anxiety *via* anticipatory responses to uncertain threats, including IUS scores, RT, and LPP amplitude to uncertain threats, were significant (all $p < 0.05$, see Figure 4). There was no significant direct effect of mindfulness on anxiety. However, anticipatory responses to uncertain threats were found to mediate the association between mindfulness and anxiety. The standardized indirect effects of IU scores, RT, and LPP amplitude on uncertain threats were −0.40, −0.05, and −0.05, respectively (all $p < 0.05$).

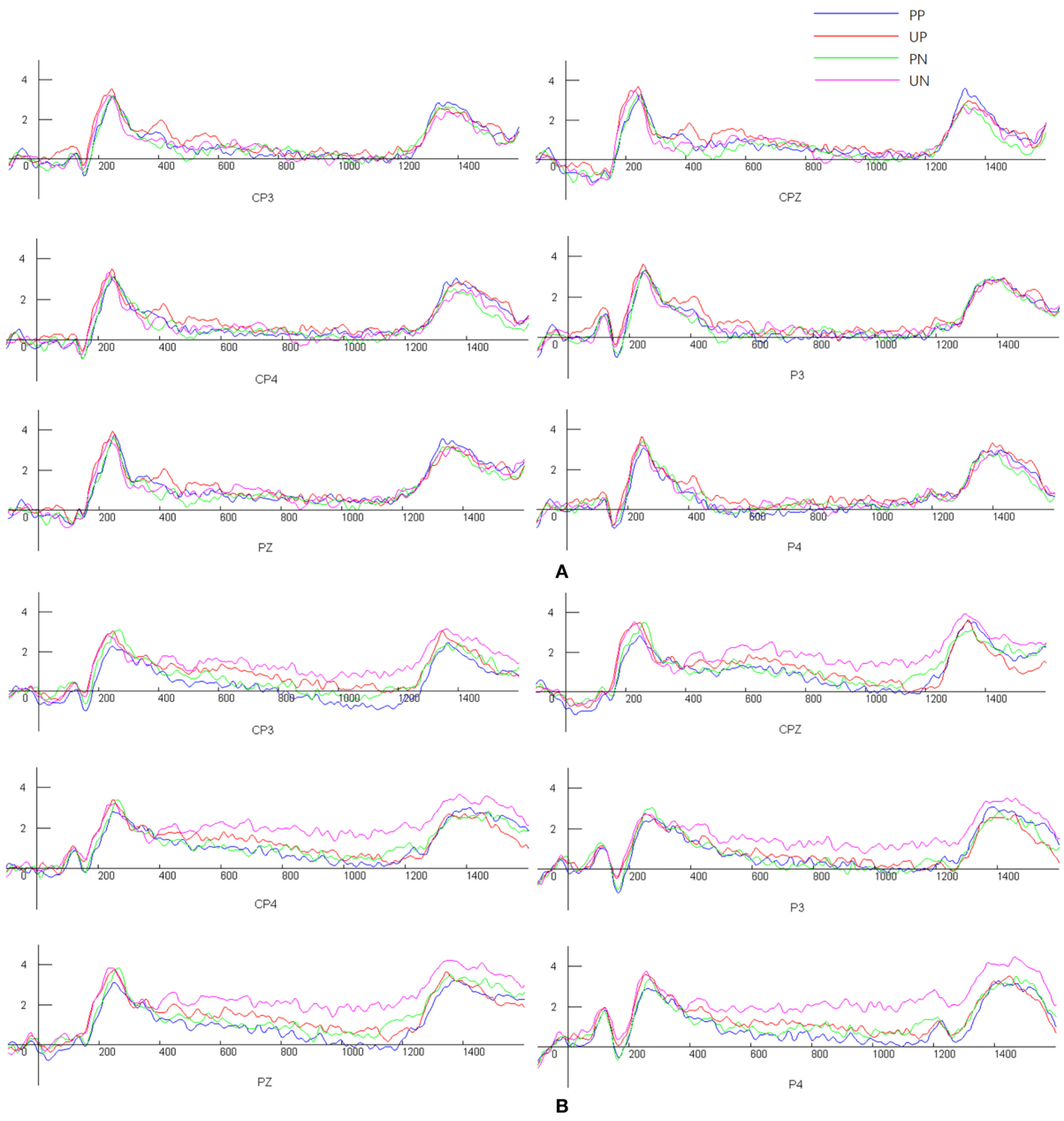

FIGURE 3
Participants' mean levels of LPP amplitude [**(A)** Low-anxious individuals, **(B)** Trait-anxious individuals]. UP, Unpredictable positive events; PP, Predictable positive events; PN, Predictable negative events; UN, Unpredictable negative events.

Discussion

Uncertainty about future threats is disruptive in anxiety. The current research aimed to explore whether an excessive threat response (both self-reported IU and behavioral and EEG responses to uncertain threats) significantly mediates the negative relationship between mindfulness and anxiety and to further investigate whether the relationship would vary according to various degrees of anxiety.

Excessive anticipatory response to uncertain threats

Substantial research has shown that excessive reactions to uncertainty play a crucial role in pathological anxiety (21, 23, 43). According to the study results, in comparison with LA individuals, there was greater self-reported IU in TA group, which supports the previous findings of a positive relationship between IU and anxiety (20). Longer RT before key presses in the

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TABLE 5 Correlations between all variables.

	1	2	3	4	5	6	7	8	9	10	11
1. HADS_A	-										
2. FFMQ	−0.61**	-									
3. IUS	0.83**	−0.63**	-								
4. RT_UP	0.32*	−0.22	0.31*	-							
5. RT_PP	0.37**	−0.27**	0.35**	0.87**	-						
6. RT_PN	0.39**	−0.26*	0.34**	0.87**	0.94**	-					
7. RT_UN	0.44*	−0.25*	0.38**	0.88**	0.88**	0.90**	-				
8. LPP_PP	0.13	−0.14	−0.02	−0.09	−0.1	−0.09	−0.07	-			
9. LPP_UP	0.17	−0.09	−0.04	−0.01	−0.07	−0.07	−0.09	0.62**	-		
10. LPP_PN	0.18	−0.10	0.09	0.14	0.05	0.06	0.14	0.61**	0.51**	-	
11. LPP_UN	0.28*	−0.30*	0.17	−0.04	0.01	0.07	0.02	0.60**	0.48**	0.57**	-

HADS-A, Anxiety subscale of Hospital Anxiety and Depression Scale; IUS, Intolerance of Uncertainty Scale; FFMQ, Five Facet Mindfulness Questionnaire; RT, Reaction time; LPP, Late positive potential; UP, Unpredictable positive events; PP, Predictable positive events; PN, Predictable negative events; UN, Unpredictable negative events.
*$p < 0.05$; **$p < 0.01$.

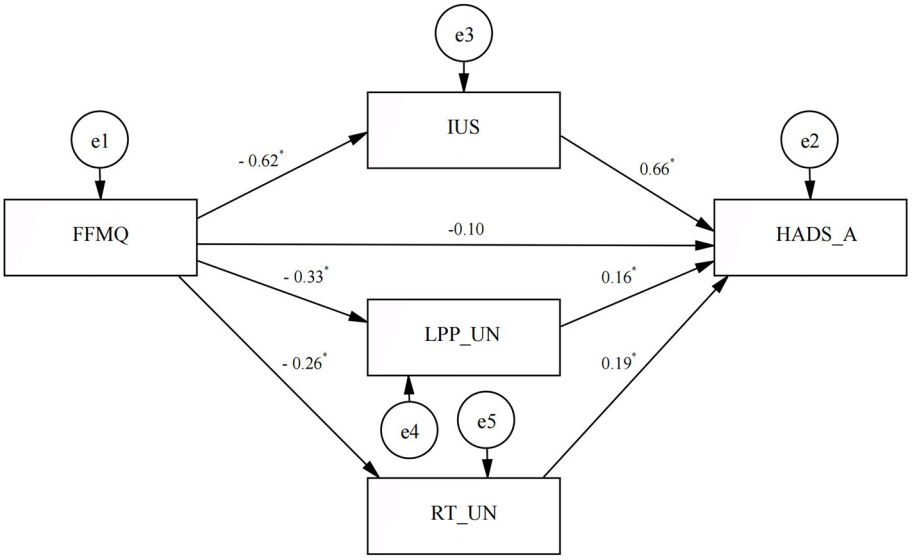

FIGURE 4
Mediation model of anticipatory response to uncertain threats to mindfulness improving anxiety. FFMQ, Five Facet Mindfulness Questionnaire; IUS, Intolerance of Uncertainty Scale; HADS-A, Anxiety subscale of Hospital Anxiety and Depression Scale; LPP-UN, the amplitude of LPP during trials signaling unpredictable negative stimuli; RT-UN, mean reaction time to the unpredictable negative stimuli. *$p < 0.05$.

uncertain negative stimuli was found in both groups, suggesting that individuals might be more involved in uncertain threats. Moreover, according to the attentional control theory, increased attention consumes limited cognitive resources and less impairs the performance efficiency of concurrent task processing (44, 45).

In addition, LPP was recorded while the subjects were exposed to predictable and unpredictable conditions. As hypothesized, the LPP amplitude of the TA group regarding uncertain threats was significantly higher than that of the LA group. Enhanced LPP during trials signals unpredictable threats, suggesting increased salience and sustained higher-level cognitive processing for these cues. Previous EEG research has investigated uncertainty-related dynamics in attentional allocation and sustained stimulus elaboration in a cued-picture paradigm. The results showed larger P2 and LPP amplitudes in uncertain conditions, suggesting that the threat uncertainty context could enhance individuals' ability for early attentional capture and late top-down allocation of attention to stimuli (21).

Further, the present study contrasted participants with high and low TA to demonstrate that this trend of excessive anticipatory response to uncertain threats is more pronounced

in the TA group. It seems that people with higher TA may demonstrate lower cognitive flexibility. They tend to prioritize uncertain threats and experience more difficulty adapting to new information (46), which may predispose them to pathological anxiety-driven behaviors (32).

Correlation analysis showed that self-reported IUS was significantly associated with RT to the images in both anxiety groups, which is consistent with a previous research (47). However, the relationship between IUS and LPP amplitude was not statistically significant. The result was inconsistent with Nelson et al.'s research (48). In their study, participants were invited to complete a passive fear generalization paradigm, and the research found that prospective IU (IUS-P, and not inhibitory IUS) was negatively correlated with LPP amplitude in the face of uncertainty, suggesting that individuals high in IUS-P might engage in cognitive avoidance during the threat uncertainty condition. Nevertheless the present study used a different version of IUS and conducted a different task that required participants' feedback. Thus, future research should adopt an experimental paradigm that includes trials that (1) only need participants' passive observation and (2) need their active feedback to further investigate the relationship between IUS and LPP amplitude.

Anticipatory threat responses mediating the benefits of mindfulness on anxiety symptoms

A previous cross-sectional study conducted by Kraemer et al. affirmed that self-reported IU mediates the relationship between mindfulness and health anxiety (10). However, research on the relationship between mindfulness, anxiety, and physiological responses (i.e., the startle reflex) in the unpredictable threat condition has shown mixed results (20). The authors explained that this might be due to the IU scale measuring a higher-order cognitive response to uncertainty involving cognitive processes such as attention, working memory, and metacognition (49) while the startle magnitude measures a lower-order defensive response to uncertainty (20), and the latter does not seem necessary for the conscious experience of any emotional cognitive state (50). Thus, in the current study, the LPP amplitude to uncertain negative stimuli was chosen as an indicator of higher-level cognitive processing (29). As we assumed, the results demonstrated significant mediating effects of excessive threat response (both self-reported IU as well as RT and LPP amplitudes to uncertain threats) on the beneficial effects of mindfulness on anxiety.

Over the past few decades, MBIs have become increasingly ideal therapeutic strategies for relieving anxiety (15, 16). Of the mindfulness elements, the non-judging awareness of the present moment's real experience was strongly associated with anxiety symptoms (7, 9). This mindful awareness of the present moment could allow anxious individuals to avoid future-oriented thinking and the overestimation of a threat's costs and related possibilities (23), thereby mitigating individuals' threat anticipation of an uncertain event from excessive expectations to more reasonable expectations and eventually to non-judgmental acceptance (23, 51). Moreover, mindful acceptance might help decrease the defensive motivation elicited by uncertainty and instead strengthen one's ability to allow an experience to be as it is, thereby relieving intolerance and inflated anxiety about potential threats (20, 21).

Smaller amplitudes of LPP during trials signaling unpredictable negative stimuli and shorter RT before key presses in uncertain threats were observed in people with higher degrees of mindfulness. It could be speculated that people with higher mindfulness would appear less blocked by uncertain threats and that under uncertainty, their cognitive resources would be more flexibly deployed according to circumstantial demands (21). Thus, higher mindfulness would contribute to alleviating negative reactions to unpredictable stimuli, in that uncertainty would be less likely to be identified as something that is unacceptable or needs to be stopped (20), ultimately relieving anxiety.

This study provides insight into mindfulness interventions for individuals with anxiety. Mindfulness practices would work well on higher-level cognitive processing by guiding anxious individuals to: (1) observe the present moment rather than worry about the future so they are less involved in the potential threat that they imagine might happen and (2) act with awareness and allow everything (including the thoughts in the mind) to just be as it is rather than trying to control them. This approach does not mean that there is no coping with mental distress, but that there is a way to respond consciously in a state of awareness without judgment (19), which could help individuals with anxiety reduce their automatic avoidance of pain since mental discomfort is often unavoidable and a failure to cope often brings more anxiety.

Limitations and future research

First, the mediating effect of the anticipatory threat responses on the association between mindfulness and anxiety was based on a cross-sectional survey. Further intervention studies are warranted, and responders and non-responders should be compared to measure the causal nature of these relationships. Second, the findings were based on 63 individuals who were either emotionally healthy or trait anxious and did

not include anyone with clinical anxiety disorders, which may undermine the significance of several relationships between variables. For example, the correlation between IU and LPP amplitude in response to uncertain threats was only marginally significant in the present study ($p = 0.056$). Third, we did not inquire about previous contemplative/meditative or body-mind practices. Such practices may affect the responses of the participants, entailing a risk of reporting bias. Given the role of social desirability in self-reported measures, the study itself may also entail a risk of self-reporting bias, which may have affected the selection of TA and LA respondents, as well as the response of the participants to other measures (e.g., IUS and HADS). In addition, the sample size was small, which limits the power of the study to detect possible relationships and mediating effects. Therefore, a large-scale intervention study involving adequately-powered samples with comparable experiences of contemplative/meditative or body-mind practices and heightened symptom levels on multiple anxiety dimensions is necessary to replicate these findings in future research.

Contribution to the field

Anxiety disorders are associated with substantial functional impairment and imposes a heavy burden on both families and society. Many studies have shown that MBIs can effectively alleviate anxiety; however, the underlying neural mechanism has not yet been elucidated. Research based on self-reported IU suggests that alleviating higher-order cognitive responses to uncertainty might mediate the effect of mindfulness on anxiety symptoms. Accordingly, the current study collected the LPP amplitudes in response to uncertain negative stimuli as the physiological indicators of higher-level cognitive processing. The results demonstrated significant mediating effects of LPP amplitude and RT on uncertain threats in the relationship between mindfulness and anxiety. The results provide further evidence that reactions to uncertain threats may play a role in the association between mindfulness and anxiety and suggest that interventions are needed to specifically target excessive anticipatory responses to uncertain threats.

Conclusion

In summary, the current research demonstrated that unpredictable, high-threat conditions might trigger a more intense anticipatory response (including self-reported IU, behavioral RT, and LPP amplitude) in TA. It further verified that mitigating anticipatory threat responses might be the potential mechanism by which mindfulness alleviates anxiety. These findings lay important groundwork for understanding the role of strong intolerance of potential threats in the development and maintenance of anxiety and may have practical implications for informing the development and optimization of mindfulness treatments for anxiety.

Data availability statement

Data used in the present analysis are included in the article/Supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Army Medical University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

YX: designed and executed the study, assisted with the data analyses, gained ethical approval, and wrote the paper. WH: recruited the subjects, collaborated with the design, and writing of the study. XY: collaborated with the recruiting of the subjects and analyzed the data. FL: collaborated with material preparation and data collection. ML: collaborated in the writing and editing of the final manuscript. All author approved the final version of the manuscript for submission.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.988577/full#supplementary-material

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Psychometric evaluation of the depression anxiety stress scale 8-items (DASS-8)/DASS-12/DASS-21 among family caregivers of patients with dementia

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Patients with dementia express a set of problematic and deteriorating symptoms, along with self-care dependency. Over time, the mental health of family caregivers of persons with dementia may be affected, putting them at a high risk for psychopathology, which may be associated with endangered wellbeing of people with dementia. This cross-sectional instrumental design study examined the psychometric properties of the Depression Anxiety Stress Scale 8-items (DASS-8), DASS-12, and DASS-21 in a convenient sample of 571 caregivers from northern Italy and southern Switzerland (mean age = 53 years, SD = 12, range = 24–89 years). A bifactor structure of the three measures had the best fit; some items of the DASS-12/DASS-21 failed to load on their domain-specific factors. The three-factor structure was invariant across various groups (e.g., gender and education), expressed adequate reliability and convergent validity, and had strong positive correlation with the three-item UCLA Loneliness Scale (UCLALS3). Distress scores did not differ among carers of different types of dementia (Alzheimer's disease vs. other types, e.g., vascular dementia). However, distress scores were significantly high among female individuals, adult children caregivers, those caring for dependent patients, and those who received help with care. For 54.9 and 38.8% of the latter, care was

provided by relatives and health professionals, respectively. Since the DASS-8 expresses adequate psychometrics comparable with the DASS-21, it may be used as a brief measure of distress in this population.

KEYWORDS

psychological distress/anxiety/depression, dementia/cognitive impairment/Alzheimer's disease/Parkinson's disease, short form of the Depression Anxiety Stress Scale 21/Depression Anxiety Stress Scale 8-items, factor structure/psychometric properties/structural validity/criterion validity/known-group validity/validation/measurement invariance/discriminant validity, old age/elders/elderly, loneliness, informal/family caregivers, spouse/adult children

Introduction

Dementia is a devastating clinical syndrome, which represents the second prevalent neurological condition after headache and the third most burdensome disease—striking more than 50 million people worldwide and contributing to an annual cost of care of more than $232 billion in the United States (1–4). The most common form of dementia is Alzheimer's disease (60–80% of dementia cases) (1, 5). However, it may develop in Parkinson's disease, cerebral vascular injury, metabolic disorders, etc. (1, 3, 6, 7). Dementia runs a progressive course. Drastic deteriorations in cognitive and functional performance develop during late stages of the disease (2, 3). Thus, dementia represents a major source of disability, with most patients expressing significant impairments in all aspects of life and high dependency in all activities of daily living (ADL). Dementia care is largely provided by family members, friends, or informal caregivers (2, 3, 8).

More than two-thirds of family caregivers of patients with dementia in the United States perform numerous medical/nursing tasks, which are usually performed by health professionals such as managing multiple medications, injections, tube feedings, and wound care (9). Family caregivers are stressed with dementia symptoms (e.g., cognitive alterations, anxiety, agitation, disinhibition, aggressive behavior, and sleep disturbances), comorbidities, and complex medication regimen (8, 9). Moreover, family caregivers are primarily elderly spouses (mean age = 62.5 ± 23.3 years, 74.1% women), who may endure physical and mental adversities associated with their own old age (e.g., age-related diseases and disability) (9, 10). As a result, caregivers frequently experience burnout, emotional distress, anxiety, sleep disturbance, poor general health, low quality of life, and social isolation (8, 9, 11–13), with higher vulnerability among women, spouses, and elders, especially those with deficient coping, social isolation, lack of training/information about the disease, poor premorbid relationship with care recipients, and high levels of negative expressed emotions (8, 9). Caregiving distress among adult-child caregivers of parents with dementia predominately originates from the impact of caregiving on children's health, schedule, and finance (14).

Orchestrated with the overall rise in distress among the general population during the COVID-19 pandemic (15), caregivers of patients with dementia have exhibited a range of mental symptoms such as mood dysfunction (e.g., anxiety and depression), sleep disturbance, loneliness, and dysfunctional eating (16, 17). Increased caregiver distress is reported to be a direct effect of COVID-19 confinement, independent of dementia stage. It is also associated with family caregivers' concerns about unavailability of paid caregivers and fear of transmitting COVID-19 infection while caring for their relatives (18). In addition, the COVID-19 era has witnessed an increase in the severity of dementia symptoms: behavioral dysfunctions, anxiety, apathy/depression, and an excessive decline in cognitive functions (18, 19). Deteriorations in dementia symptoms during COVID-19 are associated with increased caregiver distress, as well as increased intensity of caregiving and severity of caregiver burden (16, 18, 20). Distress among family and informal caregivers can adversely affect the dementia course, leading to further deteriorations in the cognitive, behavioral, and emotional symptoms of dementia, in addition to the institutionalization of dementia care recipients and increased elder abuse (8, 10). Therefore, proper assessment of distress symptomatology among dementia caregivers is necessary to mobilize actions, which are necessary to facilitate resilience in such a vulnerable group.

According to the tripartite model, general affective distress is a common component of both depression and anxiety. However, both conditions are suggested to have distinct features, which can be reliably measured (21). The Depression Anxiety Stress Scale-21 (DASS-21) has been designed and is commonly used to measure the distinct features of depression, anxiety, and stress (22). Nonetheless, subsequent investigations revealed failure of the DASS-21 to express a consistent dimensional structure (23–27), along with concerns about its psychometric equivalence across different groups both in English-speaking countries and other parts of the world (23, 28–30), as well as a ceiling effect (31). Accordingly, the scale has undergone extensive revisions, resulting in several brief forms with better psychometric properties [DASS-18 (32, 33), DASS-14 (34), DASS-13, DASS-9 (23), DASS-12 (35), and DASS-8 (36)]. Given that short scales

encourage higher response rates, the last two shortened versions of the DASS-21 have been recently tested among psychiatric patients from Korea and Saudi Arabia; healthy individuals from the USA, Australia, Saudi Arabia, and Ghana; and Australian women with chronic pelvic pain (35–38). In all studies, the DASS-8 expressed the best fit and invariance across different groups. Its internal consistency and convergent validity were close to or greater than those of the parent scale and the DASS-12. Discriminant validity analysis revealed that the subscales of the DASS-8 are more distinct than those of the parent scale and the DASS-12 (37, 38). Because of its brevity and simplicity, the DASS-8 seems to be a more attractive measure of general distress and mental symptoms of depression, anxiety, and stress. However, individuals from different cultures have their own unique ways of responding to stressful events and reporting their mental distress. Such variations may affect the manner through which they respond to the items of a symptom scale, resulting in a reporting bias, which may reduce the credibility of measurement (39). Therefore, further investigations of the psychometric characteristics of the DASS-8 in various cultural contexts and among different groups are needed, should the scale be used as a global measure of common mental symptomatology. This study aimed to evaluate the psychometric properties of the DASS-8 relative to the DAS-12 and the DASS-21 among dementia family caregivers from Italy and Switzerland. Based on previous studies, we hypothesized that the DASS measures will express a consistent three-dimensional structure and measurement invariance among caregivers from both countries. The DASS measures would congruently have positive correlations with caregiver loneliness. Based on the literature (8–10, 14), distress levels are expected to be higher among respondents who are females, spouses of care recipients, those not receiving help with care, and those caring for patients with Alzheimer's disease or who are ADL-dependent patients than in those who are males, adult children, receiving help, caring for other types of dementia, or autonomous patients.

Materials and methods

Study design, participants, and procedure

This cross-sectional study is a secondary analysis of a public dataset (40) comprising a convenient sample of Italian-speaking adult family caregivers of people with dementia. Participants were recruited through advertisements disseminated through social media and 53 dementia day-care centers in Italy and southern Switzerland. Data were collected through an online survey implemented in Research Electronic Data Capture (RedCap) during the period between 25 May and 25 June 2020. All the participants signed a digital informed consent. The data collection procedure was approved by Italian and Swiss Cantonal ethics committees (16), and the dataset is shared under the terms of creative common license (CC BY 4.0) (40). Therefore, no ethical approval was obtained for the current study.

Measures

The participants completed a self-administered questionnaire, which was in Italian and consisted of three sections. The first section inquired about participants' sociodemographic characteristics (age, gender, education, and employment), the type of dementia, level of ADL dependency, duration of dementia care provision, their relationship with the care recipient, and if they received help with dementia care (16).

Section two comprised the Italian version of the Depression Anxiety Stress Scale (DASS-21) (41) as a measure of psychological distress, depression, anxiety, and stress symptoms. The DASS-21 is composed of three subscales, and each subscale comprised seven items. The respondents would rate the intensity of their symptoms during the last week on a four-point scale, which ranged from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). The minimum and maximum total scores of the DASS-21 ranged between 0 and 63 (27, 33). In this instrumental design study, the short versions of the DASS-21 were nested within the parent scale, i.e., the data on the items of the short scales were obtained from the DASS-21 and analyzed as shown below. The DASS-8 is the shortest version of the DASS-21. It is composed of three subscales: depression (three items, e.g., felt that I had nothing to look forward), anxiety (three items, e.g., felt close to panic), and stress (two items, e.g., was using a lot of my mental energy) (36, 38). The minimum score of the DASS-8 and its subscales is 0, while the maximum scores are 24, 9, 9, and 6, respectively. The DASS-12 consists of three subscales; each subscale consists of four items. The minimum and maximum scores of the DASS-12 ranges from 0 to 36, while and the minimum and maximum scores of each of its three subscales range from 0 to 12 (35). For all the DASS measures, higher scores denote higher endorsement of mental distress symptoms. The reliability of the DASS-21, DASS-8, and DASS-12 in this sample is excellent (please see the Results section for the details).

Section three comprised the Italian version of the University of California, Los Angeles, Loneliness Scale-version 3 (UCLALS3) (42); three items of the UCLALS3 were used [lack of companionship, feel left out (exclusion), and feel isolated (isolation)], which represent three interrelated dimensions of isolation, relational connectedness, and trait loneliness. The frequency of endorsing items since the start of the COVID-19 outbreak is rated on a three-point Likert scale, which ranges from 1 (hardly never) to 3 (often). Thus, the minimum and maximum total scores of the current version of the UCLALS3 range between 3 and 9. Higher scores reflect higher loneliness (16, 42, 43). The reliability of the UCLALS3 in this study is very good (coefficient alpha = 0.87).

TABLE 1 Goodness of fit of the confirmatory factor analysis models representing the Depression Anxiety Stress Scale-8 (DASS-8), DASS-12, and DASS-21 among dementia family caregivers.

Models	Samples	χ^2	*P*	*Df*	CFI	TLI	RMSEA	RMSEA 90% CI	SRMR
Model 1	Crude	212.534	0.001	20	0.942	0.919	0.130	0.114–0.146	0.0391
1F DASS-8	Correlated error	115.331	0.001	17	0.971	0.952	0.101	0.084–0.119	0.0288
Model 2	Crude	89.717	0.001	17	0.978	0.964	0.087	0.069–0.105	0.0241
3F DASS-8	Correlated error	60.321	0.012	16	0.987	0.977	0.070	0.052–0.089	0.0178
Model 3 Bifactor DASS-8	Crude	50.737	0.001	16	0.990	0.982	0.062	0.043–0.081	0.0162
Model 4	Crude	515.206	0.001	54	0.912	0.892	0.122	0.113–0.132	0.0508
1F DASS-12	Correlated error	303.428	0.001	49	0.951	0.935	0.095	0.085–0.106	0.0390
Model 5	Crude	356.390	0.001	51	0.942	0.924	0.102	0.093–0.113	0.0450
3F DASS-12	Correlated error	336.485	0.001	46	0.945	0.924	0.103	0.092–0.113	0.0429
Model 6 Bifactor DASS-12	Crude	153.312	0.001	50	0.980	0.974	0.060	0.049–0.071	0.0253
Model 7	Crude	1,279.948	0.001	189	0.903	0.892	0.101	0.095–0.106	0.0444
1F DASS-21	Correlated error	1,070.892	0.001	185	0.921	0.910	0.092	0.89–0.97	0.0406
Model 8	Crude	997.013	0.001	186	0.928	0.918	0.087	0.082–0.093	0.0404
3F DASS-21	Correlated error	864.902	0.001	183	0.939	0.930	0.081	0.075–0.086	0.0366
Model 9 Bifactor DASS-21	Crude	701.337	0.001	184	0.954	0.947	0.070	0.065–0.076	0.0328

χ^2, chi-square; df, degrees of freedom; CFI, comparative fit index; TLI, Tucker–Lewis index; RMSEA, root mean square error of approximation; CI, confidence interval; SRMR, standardized root mean residual.

Statistical analysis

Shapiro–Wilk W test was used to examine the distribution of different versions of the DASS and the UCLALS3. Variables with a non-normal distribution were described by median (MD) and interquartile range (IQR; Q1–Q3). Variables with a normal distribution were described by mean and standard deviation. Categorical variables were described by frequencies and percentages.

Based on the findings of previous studies (36–38), the factor structures of the DASS-8 and DASS-12 were examined using confirmatory factor analysis (CFA). In this study, four models were tested: a unidimensional structure, a three-factor structure, a second-order factor structure, and a bifactor structure. The criteria used to evaluate model fit were chi-square (χ^2) index, comparative fit index (CFI), Tucker–Lewis Index (TLI), standardized root-mean-square residual (SRMR), and root-mean-square error of approximation (RMSEA). Ideally, χ^2 should be non-significant. However, χ^2 values can be greatly affected by sample size. Therefore, model fit can be parsimoniously considered good or acceptable based on the values of absolute fit measures: CFI and TLI equal to or above 0.95 and 0.90, along with SRMR and RMSEA $<$0.06 and 0.08, respectively (44, 45). Based on suggestions pointed out by modification indices, few error terms were correlated to improve the model fit.

Measurement invariance of the DASS-8/DASS-12/DASS-21 was examined at the configural, metric, scalar, and strict levels (46, 47) across groups of gender, education (compulsory, high school, and university), employment (employed and non-employed), country of residence, type of dementia (Alzheimer's disease vs. all other types), level of dependency (autonomous vs. dependent), receiving help with caregiving (yes vs. no), and relationship with care recipients (spouses vs. adult children). Models with a significant χ^2-value were considered non-invariant if ΔCFI and ΔRMSEA exceeded 0.02 and 0.015, respectively (15, 46).

To examine the known-group validity of the DASS-8/DASS-12/DASS-21, Mann–Whitney *U*-test was used to determine whether these measures and their subscales can differentiate respondents with higher distress across groups of gender, dementia type, level of dependency, and help with caregiving. To examine the discriminant validity of the DASS measures, we computed heterotrait-to-monotrait (HTMT) ratio of correlations of items comprising the DASS-8/DASS-12/DASS-21 (38, 48).

The internal consistency of the three scales and their subscales was evaluated by coefficient alpha, alpha if item deleted, and item–total correlations. The latter was also used as an indicator of convergent validity. Spearman's correlations of the DASS-8, DASS-12, and their subscales with the DASS-21 scale and its subscales were used to examine their convergent validity. The criterion validity of the DASS measures was tested by correlating their scores with the UCLALS3. Respondents with higher loneliness scores were expected to display higher levels of distress. The analyses were conducted in Amos version 24 and SPSS version 28. Significance was considered at a probability less than 0.05 in two-tailed tests.

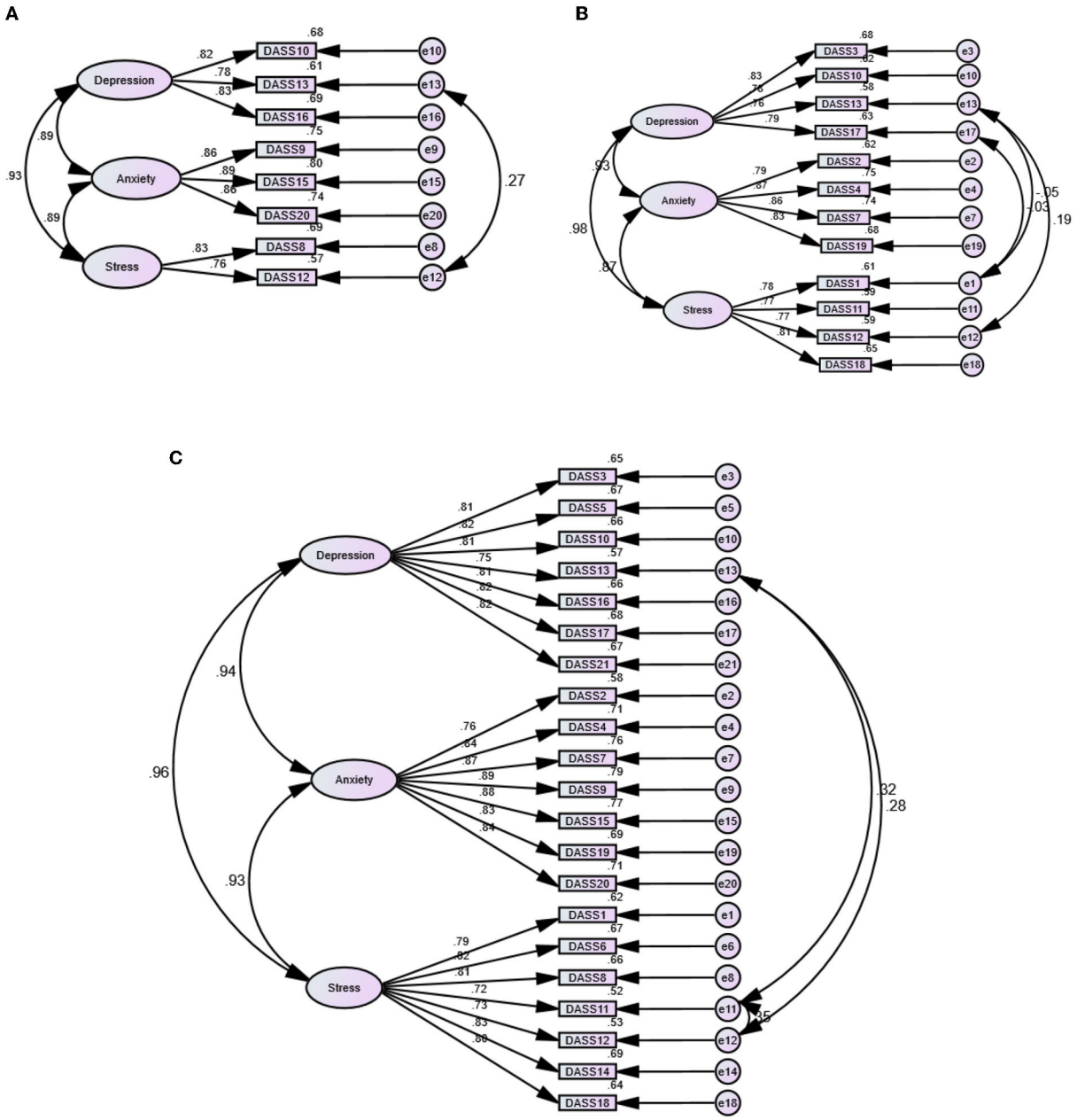

FIGURE 1
Factor structure of the Depression Anxiety Stress Scale (DASS)-21 **(C)** and its short versions: the DASS-8 **(A)** and the DASS-12 **(B)** among dementia family caregivers.

Results

Characteristics of the participants

The sociodemographic characteristics of the participants (N = 571, mean age = 53 ± 12 years, range = 24–89 years, 74.4% Italian, and 25.6% Swiss) are described in detail elsewhere (16). In brief, most of the participants were females (81.6%) and adult children of patients with dementia (71.8%). They mostly had high school education (56.4%), were employed (49.6%), provided dementia care for an average of 6.1 (SD = 4.0) years, and received help with care from other family members, friends, or health professionals (58.7%). Alzheimer's disease was the most prevalent type of dementia (55.3%), and 79.7% of patients with dementia were dependent in activities of ADL.

Results of confirmatory factor analysis and invariance analysis

Table 1 shows poor fit of the one-factor structure of the three DASS measures. The three-factor structure of the DASS-8 and the DASS-21 had good and acceptable fit, respectively. Meanwhile, RMSEA indicated misfit of the three-factor structure of the DASS-12, even when the error terms of three items were correlated. Notably, the bifactor structures of the three scales expressed the best fit among all models. In that model, all the items of the DASS-8 loaded significantly on their domain-specific factors, albeit the loadings of items 12 and 13 on the corresponding factors were below 0.3. Simultaneously, item 13 had loadings below 0.1, while items 11 and 12 failed to load on their corresponding factors in models representing the DASS-12 and the DASS-21, respectively (Supplementary materials). Given the good fit of the three-factor structure, with considerably satisfactory item loadings (Figure 1), this model was used for testing measurement invariance of the DASS scales.

As indicated in Table 2, the three-factor structures of the DASS-8, DASS-12, and DASS-21 were invariant at the configural, metric, scalar, and strict levels across all groups. Nevertheless, the DASS-8 was non-invariant at the scalar level across country groups (ΔCFI $>$ 0.02 and ΔRMSEA $>$0.15). The DASS-12 also tended to be non-invariant at the scalar level (ΔCFI $>$ 0.02).

Results of known-group validity and discriminant validity tests

Table 3 indicates significantly higher scores of all the DASS scales and their subscales among female respondents and those caring for dependent patients as hypothesized. Contrary to expectations, distress levels did not significantly vary according to the type of dementia. Also, respondents receiving help demonstrated higher scores of the DASS-8/DASS-12/DASS-21 than those who did not receive help (all p-values $<$ 0.001). Adult children caregivers expressed significantly higher levels of distress than spouse caregivers.

Based on the lenient limit of the HTMT ratio of correlations ($<$0.90), the depression and anxiety subscales of the DASS-8 and the DASS-21 were distinct from each other (HTMT ratio $=$ 0.89 and 0.90, respectively). Meanwhile, the depression and anxiety subscales of both measures expressed an overlap with the stress subscale. As for the DASS-12, all its subscales had perfect correlations with one another (Supplementary materials), except for the anxiety and stress subscales, which were marginally distinct from each other (HTMT ratio $=$ 0.88).

Results of tests of reliability, convergent validity, and criterion validity

Table 4 shows adequate reliability of the DASS-8/DASS-12/DASS-21 (coefficient alpha $=$ 0.93, 0.95, and 0.97, respectively) and their subscales (coefficient alpha ranging from 0.77 to 0.95). For the three scales, item–total correlations were considerably high, with no increase in reliability up on item deletion from any measure. The shortened versions and their subscales strongly correlated with the parent scale/subscales, suggesting adequate convergent validity. As expected, all the DASS measures had strong positive correlations with the UCLALS3, which supports their criterion validity.

Discussion

This study examined the psychometric properties of three DASS measures among dementia family caregivers, with the aim of providing a credible short version that may be promptly used for detecting mental distress in this vulnerable population. Compared with the DASS-12 and the DASS-21, the three-factor structure of the DASS-8 had the best fit. It also expressed adequate measurement equivalence, reliability, convergent validity, discriminant validity, and criterion validity relative to the longer versions.

As shown in Table 2, all the DASS measures were invariant at all levels across a wide range of participant characteristics (gender, education, employment, relationship with care recipient, type of dementia, level of dependency, and receiving help with care giving). The shortened versions of the DASS were or tended to be non-invariant at the scalar level across the country of residence. Non-invariance of these measures has been previously reported across English-speaking and Ghanian individuals. Nonetheless, they were invariant across English-speaking respondents from Australia and the United States (38). Likewise, the DASS-21 was non-invariant across countries with different languages, locations, economy, and cultural backgrounds (e.g., Poland and Russia vs. the United States and the United Kingdom as well as Germany vs. Pakistan) (28, 29). In the current study however, the respondents were recruited from a limited border area where people from both countries could fluently speak Italian. Thus, it is not expected that participants in this sample present major cultural variations. Therefore, non-invariance of the shortened version across country in the present study may be partially attributed to the considerably small number of participants in the Swiss group relative to the Italian group. Variations in group and sample sizes are reported to wrongly affect scale score equivalence. Many typical fit criteria may not be suitable in such contexts (49, 50). Moreover, the number of items, degree of factor over determination, and the level of indicator communalities can considerably affect measure fit and scale invariance (49). In

TABLE 2 Invariance of the three-factor structures of the Depression Anxiety Stress Scale 8 (DASS-8), DASS-12, and DASS-21 across different characteristics of dementia family caregivers.

Model	Groups	Invariance levels	χ^2	Df	*P*	$\Delta\chi^2$	Δdf	$p(\Delta\chi^2)$	CFI	ΔCFI	TLI	ΔTLI	RMSEA	ΔRMSEA	SRMR
DASS-8	Gender	Configural	74.110	32	0.001				0.987		0.977		0.048		0.0319
		Metric	78.903	37	0.001	4.792	5	0.442	0.987	0.000	0.981	−0.004	0.045	0.003	0.0342
		Strong	102.237	43	0.001	23.334	6	0.001	0.982	0.005	0.976	0.005	0.049	−0.004	0.0725
		Strict	120.553	52	0.001	18.316	9	0.032	0.979	0.003	0.977	−0.001	0.048	0.001	0.0880
DASS-12		Configural	398.202	96	0.001				0.941		0.919		0.074		0.05560
		Metric	410.241	105	0.001	12.039	9	0.211	0.940	0.001	0.925	−0.006	0.072	0.002	0.0596
		Strong	427.588	111	0.001	17.347	6	0.008	0.938	0.002	0.926	−0.001	0.071	0.001	0.0781
		Strict	451.821	126	0.001	24.233	15	0.061	0.936	0.002	0.933	−0.007	0.067	0.004	0.0867
DASS-21		Configural	1,146.243	366	0.001				0.929		0.919		0.061		0.0541
		Metric	1,163.750	384	0.001	17.507	18	0.489	0.929	0.000	0.923	−0.004	0.060	0.001	0.0586
		Strong	1,186.036	390	0.001	22.286	6	0.001	0.928	−0.001	0.922	0.001	0.060	0.000	0.0741
		Strict	1,233.315	414	0.001	47.278	24	0.003	0.926	−0.002	0.925	−0.003	0.059	0.001	0.0837
DASS-8	Education	Configural	157.803	68	0.001				0.973		0.967		0.048		0.0659
		Metric	158.825	73	0.001	1.021	5	0.961	0.974	0.001	0.970	−0.003	0.045	0.003	0.0651
		Strong	163.449	79	0.001	4.624	6	0.593	0.975	−0.001	0.973	−0.003	0.043	0.002	0.0686
		Strict	177.112	88	0.001	13.663	9	0.135	0.973	0.001	0.974	−0.001	0.042	0.001	0.0735
DASS-12		Configural	541.567	174	0.001				0.929		0.919		0.061		0.0839
		Metric	545.488	183	0.001	3.921	9	0.917	0.930	−0.001	0.924	−0.005	0.059	0.002	0.0872
		Strong	551.762	189	0.001	6.274	6	0.393	0.930	0.000	0.927	−0.003	0.058	0.001	0.0916
		Strict	570.557	204	0.001	18.795	15	0.223	0.929	0.0001	0.931	−0.004	0.056	0.002	0.0976
DASS-21		Configural	1,570.145	597	0.001				0.914		0.909		0.054		0.0792
		Metric	1,579.413	615	0.001	9.268	18	0.953	0.914	0.000	0.912	−0.003	0.053	0.001	0.0812
		Strong	1,587.843	621	0.001	8.430	6	0.208	0.914	0.000	0.913	−0.001	0.052	0.001	0.0828
		Strict	1,631.604	645	0.001	43.760	24	0.008	0.912	0.002	0.914	−0.001	0.052	0.00	0.0904
DASS-8	Employment	Configural	90.001	32	0.001				0.982		0.968		0.056		0.203
		Metric	94.891	37	0.001	4.890	5	0.429	0.982	0.000	0.973	−0.005	0.052	0.004	0.213
		Strong	103.106	43	0.001	8.215	6	0.223	0.981	0.001	0.975	−0.002	0.050	0.002	0.245
		Strict	122.100	52	0.001	18.994	9	0.025	0.978	0.003	0.976	−0.001	0.049	0.001	0.292
DASS-12		Configural	404.982	96	0.001				0.938		0.915		0.075		0.0476
		Metric	413.900	105	0.001	8.918	9	0.445	0.938	0.000	0.922	−0.007	0.072	0.003	0.0500
		Strong	428.248	111	0.001	14.348	6	0.026	0.936	0.002	0.924	−0.002	0.071	0.001	0.0535
		Strict	448.730	126	0.001	20.482	15	0.154	0.935	0.001	0.932	−0.008	0.067	0.004	0.0561

(Continued)

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TABLE 2 (Continued)

Model	Groups	Invariance levels	χ^2	Df	*P*	$\Delta\chi^2$	Δdf	$p(\Delta\chi^2)$	CFI	ΔCFI	TLI	ΔTLI	RMSEA	ΔRMSEA	SRMR
DASS-21		Configural	1,133.240	366	0.001				0.929		0.918		0.061		0.0410
		Metric	1,160.683	384	0.001	27.443	18	0.071	0.928	0.001	0.921	−0.003	0.060	0.001	0.0438
		Strong	1,175.832	390	0.001	15.194	6	0.019	0.927	0.001	0.921	0.000	0.060	0.000	0.0457
		Strict	1,219.078	414	0.001	43.246	24	0.009	0.925	0.002	0.924	−0.003	0.058	0.002	0.0487
DASS-8	Country	Configural	91.407	32	0.001				0.978		0.961		0.057		0.0232
		Metric	92.290	37	0.001	0.883	5	0.971	0.979	−0.001	0.969	−0.008	0.051	0.006	0.0233
		Strong	213.162	43	0.001	120.871	6	0.001	0.936	**0.043**	0.917	**0.052**	0.083	**−0.032**	0.0501
		Strict	252.328	52	0.001	39.166	9	0.001	0.925	0.011	0.919	−0.002	0.082	0.001	0.0522
DASS-12		Configural	431.680	96	0.001				0.922		0.892		0.078		0.0529
		Metric	441.663	105	0.001	9.983	9	0.352	0.921	0.001	0.901	0.001	0.075	0.003	0.0539
		Strong	577.042	111	0.001	135.379	6	0.001	0.891	**0.030**	0.871	**0.030**	0.086	−0.011	0.0711
		Strict	643.813	126	0.001	66.771	15	0.001	0.879	0.012	0.873	−0.002	0.085	0.001	0.0719
DASS-21		Configural	1,244.101	366	0.001				0.904		0.890		0.065		0.0467
		Metric	1,263.384	384	0.001	19.283	18	0.375	0.904	0.000	0.895	−0.005	0.063	0.002	0.0471
		Strong	1,430.786	390	0.001	167.402	6	0.001	0.887	0.017	0.878	0.017	0.068	−0.005	0.0668
		Strict	1,528.048	414	0.001	97.263	24	0.001	0.879	0.008	0.877	0.001	0.069	−0.001	0.0687
DASS-8	Relationship (spouse/child)	Configural	98.766	32	0.001				0.978		0.961		0.063		0.0222
		Metric	103.065	37	0.001	4.299	5	0.507	0.978	0.000	0.967	−0.006	0.058	0.005	0.0221
		Strong	115.920	43	0.001	12.855	6	0.045	0.976	0.002	0.968	−0.001	0.057	0.001	0.0288
		Strict	134.804	52	0.001	18.885	9	0.026	0.972	0.004	0.970	−0.001	0.055	0.002	0.0365
DASS-12		Configural	375.451	96	0.001				0.941		0.919		0.074		0.0438
		Metric	386.799	105	0.001	11.348	9	0.253	0.940	0.001	0.925	−0.006	0.071	0.003	0.0438
		Strong	410.290	111	0.001	23.491	6	0.001	0.937	0.003	0.925	0.000	0.072	−0.001	0.0465
		Strict	429.829	126	0.001	19.539	15	0.190	0.936	0.001	0.933	−0.008	0.068	0.004	0.0465
DASS-21		Configural	1,116.091	366	0.001				0.926		0.915		0.062		0.0363
		Metric	1,141.408	384	0.001	25.318	18	0.116	0.926	0.000	0.919	−0.004	0.061	0.001	0.0360
		Strong	1,157.691	390	0.001	16.283	6	0.012	0.925	0.001	0.919	0.000	0.061	0.000	0.0392
		Strict	1,200.414	414	0.001	42.723	24	0.011	0.923	0.002	0.922	−0.003	0.060	0.001	0.0428
DASS-8	Type of Dementia	Configural	73.426	32	0.001				0.988		0.978		0.048		0.0194
		Metric	75.085	37	0.001	1.659	5	0.894	0.989	−0.001	0.983	−0.005	0.043	0.005	0.0195

(Continued)

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TABLE 2 (Continued)

Model	Groups	Invariance levels	χ^2	Df	*P*	$\Delta\chi^2$	Δdf	$p(\Delta\chi^2)$	CFI	ΔCFI	TLI	ΔTLI	RMSEA	ΔRMSEA	SRMR
		Strong	81.576	43	0.001	6.491	6	0.370	0.989	0.000	0.985	−0.002	0.040	0.003	0.0254
		Strict	111.745	52	0.001	30.169	9	0.001	0.982	0.007	0.981	0.004	0.045	−0.005	0.0402
DASS-12		Configural	404.163	96	0.001				0.941		0.920		0.075		0.0481
		Metric	407.589	105	0.001	3.427	9	0.945	0.943	−0.002	0.928	−0.008	0.071	0.004	0.0481
		Strong	410.935	111	0.001	3.345	6	0.764	0.943	0.000	0.932	−0.004	0.069	0.002	0.0560
		Strict	448.012	126	0.001	37.077	15	0.001	0.939	0.004	0.936	−0.004	0.067	0.002	0.0560
DASS-21		Configural	1,114.320	366	0.001				0.934		0.924		0.060		0.0367
		Metric	1,126.020	384	0.001	11.700	18	0.862	0.935	−0.001	0.928	−0.004	0.058	0.002	0.0372
		Strong	1,130.640	390	0.001	4.620	6	0.593	0.935	0.000	0.930	−0.002	0.058	0.000	0.0406
		Strict	1,197.276	414	0.001	66.636	24	0.001	0.931	0.004	0.930	0.000	0.058	0.000	0.0507
DASS-8	Level of dependency	Configural	85.979	32	0.001				0.984		0.971		0.054		0.0164
		Metric	94.700	37	0.001	8.721	5	0.827	0.982	0.002	0.973	−0.002	0.052	0.002	0.0170
		Strong	99.625	43	0.001	4.925	6	0.554	0.983	−0.001	0.978	−0.005	0.048	0.004	0.0174
		Strict	106.294	52	0.001	6.669	9	0.671	0.984	−0.001	0.982	−0.004	0.043	0.005	0.0179
DASS-12		Configural	375.451	96	0.001				0.941		0.919		0.074		0.0421
		Metric	386.799	105	0.001	11.348	9	0.253	0.940	0.001	0.925	−0.006	0.071	0.003	0.0412
		Strong	410.290	111	0.001	23.491	6	0.001	0.937	0.003	0.925	0.000	0.072	−0.001	0.0438
		Strict	429.829	126	0.001	19.539	15	0.190	0.936	0.001	0.933	−0.008	0.068	0.004	0.0465
DASS-21		Configural	1,119.346	366	0.001				0.932		0.922		0.060		0.0479
		Metric	1,137.433	384	0.001	18.087	18	0.450	0.932	0.000	0.926	−0.004	0.059	0.001	0.0508
		Strong	1,153.591	390	0.001	16.157	6	0.013	0.931	0.001	0.926	0.000	0.059	0.000	0.0537
		Strict	1,179.034	414	0.001	25.443	24	0.382	0.931	0.000	0.930	−0.004	0.057	0.002	0.0587
DASS-8	Receiving help	Configural	71.359	32	0.001				0.988		0.979		0.046		0.0180
		Metric	74.438	37	0.001	3.080	5	0.688	0.988	0.000	0.982	−0.003	0.042	0.004	0.0193
		Strong	77.536	43	0.001	3.097	6	0.797	0.989	−0.001	0.986	−0.004	0.038	0.004	0.0231
		Strict	80.204	52	0.001	2.669	9	0.976	0.991	−0.002	0.991	−0.005	0.031	0.007	0.0234
DASS-12		Configural	414.540	96	0.001				0.937		0.914		0.076		0.0398
		Metric	418.887	105	0.001	4.346	9	0.887	0.938	−0.001	0.922	−0.008	0.072	0.004	0.0399
		Strong	438.250	111	0.001	19.363	6	0.004	0.936	0.002	0.923	−0.001	0.072	0.000	0.0441
		Strict	455.058	126	0.001	16.809	15	0.330	0.935	0.001	0.932	−0.009	0.068	0.004	0.0460
DASS-21		Configural	1,166.435	366	0.001				0.927		0.916		0.062		0.0402
		Metric	1,182.852	384	0.001	16.418	18	0.563	0.927	0.000	0.920	−0.004	0.060	0.002	0.0420
		Strong	1,194.925	390	0.001	12.073	6	0.060	0.927	0.000	0.921	−0.001	0.060	0.00	0.0428
		Strict	1,227.466	414	0.001	32.541	24	0.114	0.926	0.001	0.925	−0.004	0.059	0.001	0.0449

χ^2, chi-square; df, degrees of freedom; CFI, comparative fit index; TLI, Tucker–Lewis index; RMSEA, root mean square error of approximation; CI, confidence interval; SRMR, standardized root mean residual, values in bold indicate variance or tendency toward variance.

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TABLE 3 Known-group validity of the Depression Anxiety Stress Scales (DASS-8, DASS-12, and DASS-21) among dementia family caregivers.

DASS versions	Gender		Dependency level		Receiving help		Relationship		Dementia type	
	U	*z*	*U*	*z*	*U*	*Z*	*U*	*z*	*U*	*z*
DASS-8	17,268.0***	−4.59	20,755.0***	−3.56	29,328.0**	−5.26	19,325.5***	−3.33	39,309.5	−0.50
Depression	19,232.0***	−3.32	22,206.5**	−2.66	30,074.0**	−4.90	19,585.5***	−3.18	40,106.5	−0.09
Anxiety	16,333.5***	−5.23	20,627.5***	−3.66	29,215.0**	−5.35	19,398.5***	−3.30	38,408.0	−0.98
Stress	19,165.0**	−3.39	21,642.5**	−3.04	32,017.5**	−3.93	21,351.5*	−1.98	38,719.5	−0.80
DASS-12	16,452.5***	−5.13	20,835.0***	−3.50	28,614.0**	−5.63	18,907.5***	−3.62	38,779.0	−0.77
Depression	17,260.5***	−4.61	21,783.0**	−2.92	29,357.5**	−5.26	19,429.0**	−3.27	38,762.5	−0.78
Anxiety	15,847.5***	−5.54	20,514.0***	−3.72	28,690.5**	−5.60	18,618.0***	−3.83	38,647.0	−0.84
Stress	19,122.5**	−3.38	21,675.0**	−2.99	30,515.0**	−4.67	20,497.5*	−2.54	39,258.0	−0.53
DASS-21	16495.0***	−5.10	20598.0***	−3.65	28696.0**	−5.58	18995.5***	−3.56	39482.5	−0.41
Depression	17,611.0***	−4.37	21,609.5**	−3.02	29,316.0**	−5.27	19,700.5**	−3.08	39,211.5	−0.55
Anxiety	15,868.5***	−5.52	20,352.0***	−3.81	28,649.5**	−5.61	18,726.5***	−3.75	38,741.0	−0.79
Stress	17,731.0***	−4.29	21,271.0**	−3.23	29,717.0**	−5.06	19,955.0**	−2.91	39,300.0	−0.51

DASS, Depression Anxiety Stress Scale; U, Mann–Whitney U-test.
*, **, ***Differences are significant at a level of 0.05, 0.01, and 0.001, respectively.

this respect, models with small degrees of freedom (df) tend to express inflated RMSEA (51, 52). This was notable in the model examining the DASS-8 compared with that of the DASS-12, which also exhibited inflation in ΔCFI—a more reliable measure of misfit in small scales than RMSEA (51, 52). Accordingly, future studies investigating the invariance of these shortened versions need to take the influence of sample size on scale equivalence into consideration.

As for the tests of known-group validity, the DASS measures significantly identified distressed groups (Table 3). As expected, female carers and those caring for ADL-dependent patients had higher distress levels than male carers and those caring for autonomous patients, with no difference between Alzheimer's disease and other types of dementia. More than half the respondents (58.7%) stated that they received help with caring for patients with dementia. In contradiction to our hypothesis, those receiving help expressed greater levels of distress than those who did not receive help. Dementia caregiving is primarily provided by families (in up to 65% of cases) (18), and the worst levels of caregiver distress are largely reported among those caring for severe cases than those caring for mild cases (18, 19). For those who reported receiving help, 55.3% of their patients had Alzheimer's disease, and 79.7% of patients were not able to perform ADL. Therefore, ADL dependency, which may be associated with dementia severity, is the possible cause of distress in this group. In addition, caregiving is also reported to negatively influence the health of caregivers (14). Accordingly, those who perceive their health as deteriorating as a result of extensive caregiving are more likely to ask for help. For 54.9, 38.8, and 6.3% of the respondents who indicated that their patients received supplementary care, care was provided by another relative, nurse, or friend, respectively. Caregiver distress during the COVID-19 pandemic is associated with fear of the absence of paid caregivers as well as fear that contact with people who assist with instrumental activities may transmit this virulent infection to their patients (18). In addition, caregiving interferes with adult children's work schedule, while hiring health professionals to care for this chronic condition may represent a persistent financial burden (14).

Based on an existing review, we hypothesized that spouse caregivers would express higher levels of distress than adult children caregivers (8). Paradoxically, the latter demonstrated more distress than spouse caregivers. This finding can be related to the fact that the pandemic has created a lot of challenges for younger groups such as increased time spent caring for their children due to school closure, loss of jobs/income, and social isolation imposed by the lockdown. Meanwhile, spouses are older and more likely to be retired, with a greater possibility of being more home-bound than the youth. Moreover, age is reported as a protective factor against distress and trauma during the pandemic (15).

Discriminant validity tests show that the depression and anxiety subscales of the DASS-8 and the DASS-21 were distinct from each other. Thus, the DASS-8/DASS-21 may be used to distinguish the symptoms of depression from those of anxiety, albeit the stress subscale was overlapping with both subscales in both measures. A total of two previous studies revealed that most subscales of the DASS-8 were distinct from each other—the stress and anxiety subscales were overlapping with one another (37, 38). However, that was not true for the DASS-12, which could only discriminate anxiety symptoms from stress symptoms in the current study. All the DASS measures positively correlated with the UCLALS3 at the same level of significance, indicating usefulness of the DASS-8, DASS-12, and DASS-21 as criterion variables. All these measures also demonstrated comparably adequate internal consistency

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and convergent validity, as noted by high values of item–total correlations and correlations of the shortened versions with the parent scale/subscales.

This study expands the literature by using various techniques to examine three DASS measures in a particularly distressed group (dementia family caregivers) from two European countries during the COVID-19 outbreak. Given that the psychometrics of the DASS-8 were adequately similar to those of longer DASS scales, it may be easier to frequently screen for possible psychopathology among dementia caregivers using this brief version. Scale brevity is a key advantage, especially for a scale that inherits the validity of the parent scale since response rates decrease with the administration of long scales (51, 52). The study also enjoys the merit of repurposing already available public data to generate new knowledge without consuming extensive economic and intellectual resources. Despite these advantages, a number of limitations should be noted. The recruitment and data collection methods entail a risk for selection bias where only those using social media and a smart phone could participate in the present study. Another possibility of selection bias stems from the fact that most of the participants of the study are women. Women may vary in the extent of their emotional experience and expression of distress from men (53)—in fact, greater levels of distress among women were detected in our analysis. Nonetheless, the DASS measures were invariant across genders, indicating that they are less likely to be biased by women's tendency to express more negative emotions than men. Additionally, the UCLALS3 expressed adequate internal consistency, denoting that it enjoys the basic psychometric properties of a scale. Nevertheless, statistics on the different types of validity of this three-item scale as an adequate measure of loneliness are lacking, putting our test of criterion validity at jeopardy. The results may not be generalized because of the cross-sectional design, the convenience sample, and the limited time and location of data collection (during an early stage of a prolonged pandemic and from a border region between Italy and Switzerland). Examining the invariance of the DASS measures across those two border regions may not be sufficient to reflect invariance across countries. Although the sample size meets the requirements for CFA analysis based on 21 items of the DASS-21 (20 responses per one item), multigroup comparisons across countries may not be that robust because of the vivid variation in the number of respondents in the country groups. Using an adequate number of groups and participants in groups is necessary for future investigations to properly examine the measurement invariance of the DASS-8/DASS-12 across more European and non-European countries. Multiple participation may represent a threat to data integrity since the survey was conducted online, and there is no information available on the control of the number of participations per person. Moreover, the respondents were included based on self-reporting their state as family caregivers

TABLE 4 Internal consistency, convergent validity, and criterion validity of the Depression Anxiety Stress Scale (DASS) 21, DASS-12, DASS-8, and their subscales among dementia family caregivers.

	DASS-8	Depression	Anxiety	Stress	DASS-12	Depression	Anxiety	Stress	DASS-21	Depression	Anxiety	Stress
MD (IQR)	15 (8–19)	6 (3–8)	4 (1–7)	4 (2–5)	21 (12–28)	7 (4–10)	6 (2–9)	8 (6–10)	38 (19–49)	13 (7–17)	10 (4–16)	14 (9–17)
Coefficient alpha	0.933	0.850	0.904	0.773	0.948	0.866	0.902	0.859	0.973	0.929	0.945	0.923
Range of corrected item–total correlations	0.739–0.823	0.699–0.743	0.802–0.822	0.633	0.717–0.801	0.701–0.756	0.752–0.816	0.635–0.738	0.701 –0.850	0.718–0.806	0.742–0.858	0.730–0.788
Range of alpha if-item-deleted	0.920–0.925	0.770–0.818	0.853–0.870	—-	0.942–0.946	0.812–0.839	0.861–0.884	0.806–0.854	0.971–0.972	0.914–0.923	0.933–0.943	0.907–0.914
Correlation with the corresponding subscale of the DASS-21	–	0.945**	0.948**	0.928**	–	0.974**	0.968**	0.967**	–	–	–	–
Correlation with the DASS-21	0.977**	0.894**	0.929**	0.852**	0.987**	0.945**	0.903**	0.903**	–	0.959**	0.954**	0.943**
Correlation with UCLALS3	0.737**	0.688**	0.724**	0.594**	0.735**	0.729**	0.673**	0.644**	0.748**	0.731**	0.724**	0.679**

MD, median; IQR, interquartile range; DASS, Depression Anxiety Stress Scale; UCLALS3, the 3-item University of California, Los Angeles, Loneliness Scale-version 3.
**Correlations are significant at a level of 0.01.

of people with dementia. Not using credible references (e.g., the medical record for the care-recipients) to confirm that the respondents were really caregivers may entail a risk for selection bias.

Conclusion

The DASS-8 displayed a better factor structure than longer versions, and all its other psychometrics (measurement invariance, reliability, convergent validity, criterion validity, and known-group and discriminant validity) were adequate, compared with longer versions. Because the course of dementia is chronic and progressive, considerable attention should be paid to the identification of high levels of distress among caregivers, especially female carers, adult children of patients with dementia, those with highly dependent patients, and those who ask for supplementary care. The DASS-8 can be a useful brief measure for achieving this aim.

Data availability statement

Publicly available datasets were analyzed in this study. The dataset supporting the conclusions of this article is available in Zenodo repository at https://zenodo.org/record/4748652#.YdbwiWhBw2w.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1012311/full#supplementary-material

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Living alone is associated with a higher prevalence of psychiatric morbidity in a population-based cross-sectional study

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Background: Living alone has been linked to poor mental health, however large-scale epidemiological studies on the association between living alone and psychiatric morbidity including depression and anxiety are lacking. The aim of this study was to investigate this issue in a large Taiwanese cohort.

Methods: In this cross-sectional study, we enrolled 121,601 volunteers from 29 community recruitment stations in Taiwan and divided them into two groups based on whether or not they lived alone. Psychiatric morbidity was defined as a Generalized Anxiety Disorder 2-item score $\geq$ 3, Patient Health Questionnaire 2-item score $\geq$ 3, or self-reported depression. Logistic regression was used to explore the associations between living alone and psychiatric morbidity.

Results: The participants who lived alone had a higher prevalence of psychiatric morbidity [odds ratio (OR) = 1.608, 95% confidence interval (CI) = 1.473 to 1.755] after adjusting for potential confounders. In a subgroup analysis, married subjects who lived alone and divorce/separation (OR = 2.013, 95% CI = 1.763 to 2.299) or widowing (OR = 1.750, 95% CI = 1.373 to 2.229) were more likely to have psychiatric morbidity than those who were married and not living alone.

Conclusions: Our findings suggest that living alone is a risk factor for psychiatric morbidity, especially for married subjects who live alone in concordance with divorce, separation, or the death of a spouse.

KEYWORDS

dependence, depression, anxiety, Psychiatric disorders, psychiatric distress, psychiatric morbidities, living alone

Introduction

In recent years, the increase in unmarried, later marriage, and divorce rates has caused the pattern of marriage and family to change dramatically. A smaller family size has led to a growth in single-person households (1), and social isolation and a lack of contact has been associated with health issues such as mental disorders, dementia, poor nutrition, and cardiac disease (2–4). Worldwide, more than 300 million people are affected by depression, and more than 250 million live with anxiety disorders (5). According to a cross-sectional survey in Taiwan, the prevalence of potentially common mental diseases, including non-psychotic, depression, and anxiety disorders, doubled from 11.5% in 1990 to 23.8% in 2010 (6). Proper care and treatment for these patients can reduce mortality and extend life expectancy (7). Moreover, an increase in the prevalence of these common mental diseases would result in tremendous medical and social costs (8, 9), making it crucial to determine the risk factors and comorbidities associated with them.

Researchers have investigated the relationship between living alone and mental health, and found that social isolation increases the risk of common mental diseases (10). However, these studies mainly focused on the effects of depression on elderly populations, rather than on the general or young populations. In addition, only a few have mentioned the association between living alone and other psychiatric conditions, such as anxiety, and most only included a small number of subjects (11). Furthermore, as the number of single-person households increases, mental disorders could also affect younger people who are unmarried or divorced as well as elderly populations.

Psychiatric morbidity is a symptom-based medical term generally applied to those aware of their condition, including a variety of mental illnesses, such as depression, anxiety, schizophrenia, bipolar disorder, et cetera, which is well–suited for exploring the association between living alone and mental health (12). One advantage of using psychiatric morbidity to test our hypothesis is that it not only covers depression, but also other psychiatric disorders as well. Another advantage is that psychiatric morbidity often represents the symptomatic group, which makes our results more clinically meaningful (12). Because living alone has been associated with loneliness (13), social support (14), and substance use (15), which are risk factors for psychiatric morbidity, we hypothesize that living alone is associated with psychiatric morbidity. Previously, numerous studies have documented that education (16), smoking (17), drinking (18), chronic disorders (19), stressful life events (20) and obesity (21) are associated with psychiatric morbidity; however, only a few have mentioned the association between living alone and psychiatric morbidity, and most only included a small number of subjects (10). The goals of this study were to determine the association between living alone and psychiatric morbidity.

Materials and methods

Data source and study population

The data used in this study were from a population-based dataset derived from 29 community recruitment stations in Taiwan since 2008, details of which have been described in our previous publications (22–24). In brief, all subjects were enrolled as volunteers and completed several questionnaires including basic profile, habitus, past history, Generalized Anxiety Disorder 2-item (GAD-2) and Patient Health Questionnaire 2-item (PHQ-2). They also underwent physical examinations during which body weight and height were measured and blood tests were performed. Before enrollment, all subjects understood the purpose, interests, pros and cons of our research and signed a consent form. All researchers followed the Declaration of Helsinki throughout the study, which was approved by the Institutional Review Board of our institute (KMUHIRB-E(I)-20210058).

Variables

The variables used in this study came from the aforementioned questionnaires, physical examinations, and blood tests. Data on age, gender, smoking status, drinking status, exercise status, marital status, educational status, medical history, GAD-2 and PHQ-2 scores, were obtained from the questionnaires. Data on body mass index (BMI) and waist circumference were obtained from the physical examinations, and data on serum creatinine and chronic kidney disease (defined as an estimated glomerular filtration rate < 60 ml/min/1.73 m^2) were obtained from the blood tests.

Living arrangements and marital status

Each subject would need to fill out a questionnaire about their living arrangements and marital status. Regarding living arrangements, there are two options in the questionnaire: (1) living alone and (2) living with family or others. Based on the subjects' responses, they were divided into living alone (+) and living alone (-). Regarding marital status, there are four options in the questionnaire: (1) unmarried (single/never married), (2) married, (3) divorced or separated, and (4) widowed. We further combined living arrangements with marital status, and subjects were subdivided into 6 groups: (1) living alone (+) and unmarried, (2) living alone (+) and married, (3) living alone (+) and divorce/separation, (4) living alone (+) and widowing, (5) living alone (-) and unmarried, (6) living alone (-) and married.

Psychiatric morbidity

Psychiatric morbidity was defined as depression and anxiety in this study. We used the PHQ-2, GAD-2, and self-reported depression to assess the presence or absence of psychiatric morbidity. The PHQ-2 uses the following two questions to assess a subject's depressive condition in the last 2 weeks: "Do you feel little interest or pleasure in doing things? (0 = not at all; 1 = several days; 2 = more than half the days; 3 = nearly every day)" and "Do you feel down, depressed, or hopeless? (0 = not at all; 1 = several days; 2 = more than half the days; 3 = nearly every day)". The GAD-2 also uses two questions to assess a subject's anxiety in the last 2 weeks as follows: "Do you feel nervous, anxious, or on edge? (0 = not at all; 1 = several days; 2 = more than half the days; 3 = nearly every day)" and "Do you feel unable to stop or control worrying? (0 = not at all; 1 = several days; 2 = more than half the days; 3 = nearly every day)". Participants with a PHQ-2 score of 3 to 6 were considered to have depressive tendencies, and those with a GAD-2 score of 3 to 6 were considered to have anxiety tendencies. We further defined psychiatric morbidity as a GAD-2 score $\geq$ 3, PHQ-2 score $\geq$ 3, or self-reported depression.

Statistical analysis

We used descriptive statistics to describe the profiles of all subjects. Continuous variables are expressed as means and standard deviations, and categorical variables are expressed as numbers and percentages. We then divided the subjects into two groups according to whether or not they lived alone, and the differences between groups were measured using the independent *t* test and chi-square test. The possible confounders of the association between living alone and psychiatric morbidity were identified through literature reviews, including age (25), sex (25), obesity (21), educational status (16), smoking (17), drinking (18), physical activity (26), marital status (27) and chronic diseases (heart disease, asthma, chronic obstructive pulmonary disease, gastrointestinal problems, hypertension, diabetes mellitus, dyslipidemia, gout, osteoporosis, chronic kidney disease, neurological diseases and substance abuse) (19, 28–30). To further identify the risk factors, these possible confounders were entered into the feature selection process using the least absolute shrinkage and selection operator (LASSO) regression, by assigning each training observation to be subdivided randomly into 10 parts, then by a method of an automated 10-fold cross-validation (31). We further used univariable and multivariable logistic regression to test the association of each variable with psychiatric morbidity. Finally, we conducted a subgroup analysis to explore the association of marriage and dependency with psychiatric morbidity. In this study, a p value < 0.05 indicated a significant association. Our analysis was performed using R (version 3.6.2, R Foundation for Statistical Computing, Wien, Austria), SAS (version 9.4, SAS Institute Inc., Cary, NC, United States) and SPSS (version 20.0, IBM Corp, Armonk, NY, United States).

Results

Profiles of the participants

A total of 121,601 participants with sufficient data were included in our analysis. Their average age was 50 years, 27.3% smoked, 8.5% drank alcohol, 86.4% were married, 3.6% had self-reported diagnosed depression, 4.5% had psychiatric morbidity and 8.1% lived alone (Table 1). Among the 16,582 participants who completed the PHQ-2 and GAD-2, the average PHQ-2 score was 0.53, the GAD-2 score was 0.56, 4.2% had a PHQ-2 $\geqq$ 3, and 5.4% had a GAD-2 $\geqq$ 3. The subjects' past medical histories are also listed in Table 1. The subjects who lived alone (n = 9,828) had a lower BMI, lower waist circumference, higher proportion of smoking, drinking, PHQ-2 $\geqq$ 3, GAD-2 $\geqq$ 3, psychiatric morbidity, and more were unmarried than those who did not live alone. Concerning past medical history, the subjects who lived alone were more likely to have diabetes, respiratory diseases, gastrointestinal diseases, orthopedic diseases, neurological diseases and self-reported diagnosed depression than those who did not live alone (Table 1).

Parameters associated with psychiatric morbidity in univariable binary logistic analysis

By performing LASSO regression, we excluded three variables, including drinking status, exercise and chronic kidney disease, that had minimal effects on psychiatric morbidity (Supplementary Figure 1 and Supplementary Table 1). The remaining 24 variables were entered into further analysis. In univariable binary logistic analysis, female gender, smoking, diabetes mellitus, dyslipidemia, cardiovascular diseases, respiratory diseases, orthopedic diseases, gastrointestinal diseases, neurological diseases, and living alone were associated with a higher prevalence of psychiatric disorders (Table 2). The subjects who lived alone had a higher prevalence of psychiatric morbidity with an odds ratio (OR) of 1.831 [95% confidence interval (CI) = 1.689 to 1.986, p <0.001]. Conversely, being married and having a high degree of education were associated with a lower prevalence of psychiatric disorders (Table 2).

TABLE 1 Profiles of participants.

Characteristics	Total ($n = 121,601$)	Living alone (+) ($n = 9,828$)	Living alone (-) ($n = 111,773$)	p value
Age, yr	50 ± 11	50 ± 12	50 ± 11	0.311
Male gender, *n* (%)	43,699 (35.9)	3,000 (30.5)	40,699 (36.4)	<0.001
Body mass index, kg/m2	24.2 ± 3.8	24.0 ± 4.0	24.2 ± 3.8	<0.001
Waist circumference, cm	83.3 ± 10	82.7 ± 10.8	83.4 ± 10.2	<0.001
Smoking status, ever, *n* (%)	33,156 (27.3)	2,765 (28.1)	30,391 (27.2)	0.044
Drinking status, ever, *n* (%)	10,357 (8.5)	892 (9.1)	9,465 (8.5)	0.039
Regular exercise, yes, *n* (%)	49,304 (40.5)	4,073 (41.4)	45,231 (40.5)	0.059
Marital status, married, *n* (%)	105,059 (86.4)	5,409 (55.0)	99,650 (89.2)	<0.001
Education status, ≧College, *n* (%)	70,475 (58.0)	6,054 (61.6)	64,421(57.6)	<0.001
Hypertension, *n* (%)	14,887 (12.2)	1,185 (12.1)	13,702 (12.3)	0.574
Diabetes, *n* (%)	6,276 (5.2)	569 (5.8)	5,707 (5.1)	0.003
Dyslipidemia, *n* (%)	9,041 (7.4)	759 (7.7)	8,282 (7.4)	0.261
CAD, *n* (%)	1,562 (1.3)	142 (1.4)	1,420 (1.3)	0.146
Valvular heart disease, *n* (%)	5,092 (4.2)	513 (5.2)	4,579 (4.1)	<0.001
Asthma. *n* (%)	4,301 (3.5)	408 (4.2)	3,893 (3.5)	0.001
COPD, *n* (%)	1,390 (1.1)	154 (1.6)	1,236 (1.1)	<0.001
Osteoporosis, *n* (%)	4,994 (4.1)	535 (5.4)	4,459 (4.0)	<0.001
Gout, *n* (%)	4,675 (3.8)	289 (2.9)	4,386 (3.9)	<0.001
GERD, *n* (%)	16,666 (13.7)	1,463 (14.9)	15,203 (13.6)	<0.001
Peptic ulcer, *n* (%)	17,701 (14.6)	1,531 (15.6)	16,170 (14.5)	0.003
IBS, *n* (%)	3,026 (2.5)	275 (2.8)	2,751 (2.5)	0.041
CKD, *n* (%)	1,951 (1.6)	178 (1.8)	1,773 (1.6)	0.092
Parkinson's disease, *n* (%)	131 (0.1)	11 (0.1)	120 (0.1)	0.872
Dementia, *n* (%)	37 (0.2)	7 (0.1)	30 (0.0)	0.027
Schizophrenia, *n* (%)	237 (0.2)	34 (0.3)	203 (0.2)	0.001
Substance abuse, *n* (%)	44 (0.0)	9 (0.1)	35 (0.0)	0.008
Self-reported depression	4,362 (3.6)	607 (6.2)	3,755 (3.4)	<0.001
PHQ-2	0.53 ± 0.99	0.73 ± 1.15	0.51 ± 0.97	<0.001
PHQ-2 ≧ 3*	699 (4.2)	87 (6.4)	612 (4.0)	<0.001
GAD-2	0.56 ± 0.97	0.73 ± 1.15	0.54 ± 0.96	<0.001
GAD-2 ≧ 3*	896 (5.4)	117 (8.6)	779 (5.0)	<0.001
Psychiatric morbidity	5,414 (4.5)	729 (7.4)	4,685 (4.2)	<0.001

CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; GERD, gastroesophageal reflux disease; IBS, irritable bowel syndrome; CKD, chronic kidney disease; PHQ-2, Patient Health Questionnaire 2-item; GAD-2, Generalized Anxiety Disorder 2-item.
*There were 16,582 participants providing data on GAD-2 and PHQ-2.

Parameters associated with psychiatric morbidity in multivariate binary logistic analysis

In multivariable binary logistic analysis, female gender, waist circumference, smoking, diabetes mellitus, dyslipidemia, cardiovascular diseases, respiratory diseases, orthopedic diseases, gastrointestinal diseases, neurological diseases, and living alone were associated with a higher prevalence of psychiatric disorders (Table 3). The subjects who lived alone had a higher prevalence of psychiatric morbidity with an OR of 1.608 (95% CI = 1.473 to 1.755, p <0.001) after adjusting for potential confounders. In contrast, age, BMI, being married, and having a high degree of education were associated with a lower prevalence of psychiatric disorders (Table 3). We further analyzed males and females separately, and the results were similar to the results of the whole study population (Supplementary Table 2).

TABLE 2 Parameters associated with psychiatric morbidity in univariable binary logistic analysis.

Parameters	Odds ratio (95% CI)	*P* value
Age (per 1 year)	1.002 (1.000 to 1.005)	0.086
Female gender (vs. *male gender*)	1.683 (1.581 to 1.791)	<0.001
Body mass index (per 1 kg/m^2)	0.996 (0.989 to 1.003)	0.277
Waist circumference (per 1 cm)	1.001 (0.999 to 1.004)	0.338
Smoking status, ever (vs. never)	1.244 (1.173 to 1.319)	<0.001
Marital status, married (vs. no)	0.805 (0.747 to 0.867)	<0.001
Education status, ≧College (vs. no)	0.846 (0.809 to 0.884)	<0.001
Hypertension, yes (vs. no)	1.264 (1.171 to 1.366)	<0.001
Diabetes mellitus, yes (vs. no)	1.485 (1.336 to 1.650)	<0.001
Dyslipidemia, yes (vs. no)	1.700 (1.561 to 1.853)	<0.001
CAD, yes (vs. no)	1.804 (1.494 to 2.177)	<0.001
Valvular heart disease, yes (vs. no)	2.115 (1.910 to 2.342)	<0.001
Asthma, yes (vs. no)	2.016 (1.802 to 2.254)	<0.001
COPD, yes (vs. no)	2.128 (1.766 to 2.564)	<0.001
Osteoporosis, yes (vs. no)	1.853 (1.664 to 2.064)	<0.001
Gout, yes (vs. no)	0.768 (0.656 to 0.900)	0.001
GERD, yes (vs. no)	2.244 (2.106 to 2.391)	<0.001
Peptic ulcer, yes (vs. no)	2.048 (1.921 to 2.182)	<0.001
IBS, yes (vs. no)	3.023 (2.698 to 3.387)	<0.001
Parkinson's Disease, yes (vs. no)	3.877 (2.407 to 6.247)	<0.001
Dementia, yes (vs. no)	9.096 (4.492 to 18.418)	<0.001
Schizophrenia, yes (vs. no)	6.857 (5.085 to 9.249)	<0.001
Substance abuse, yes (vs. no)	7.166 (3.620 to 14.186)	<0.001
Living alone, yes (vs. no)	1.831 (1.689 to 1.986)	<0.001

Abbreviations are as Table 1, CI, Confidence interval.

TABLE 3 Parameters associated with psychiatric morbidity in multivariate binary logistic analysis.

Parameters	Odds ratio (95% CI)	*p* value
Age (per 1 year)	0.992 (0.989 to 0.995)	<0.001
Female gender (vs. *male gender*)	2.359 (2.180 to 2.553)	<0.001
Body mass index (per 1 kg/m^2)	0.966 (0.953 to 0.979)	<0.001
Waist circumference (per 1 cm)	1.016 (1.010 to 1.021)	<0.001
Smoking status, ever (vs. never)	1.771 (1.650 to 1.900)	<0.001
Marital status, married (vs. no)	0.899 (0.824 to 0.980)	0.015
Education status, ≧College (vs. no)	0.856 (0.806 to 0.909)	<0.001
Hypertension, yes (vs. no)	1.184 (1.084 to 1.292)	<0.001
Diabetes mellitus, yes (vs. no)	1.263 (1.125 to 1.417)	<0.001
Dyslipidemia, yes (vs. no)	1.358 (1.234 to 1.495)	<0.001
CAD, yes (vs. no)	1.397 (1.143 to 1.708)	0.001
Valvular heart disease, yes (vs. no)	1.569 (1.411 to 1.744)	<0.001
Asthma, yes (vs. no)	1.632 (1.453 to 1.834)	<0.001
COPD, yes (vs. no)	1.482 (1.218 to 1.803)	<0.001
Osteoporosis, yes (vs. no)	1.418 (1.264 to 1.591)	<0.001
Gout, yes (vs. no)	0.844 (0.713 to 0.999)	0.048
GERD, yes (vs. no)	1.661 (1.550 to 1.780)	<0.001
Peptic ulcer, yes (vs. no)	1.618 (1.510 to 1.733)	<0.001
IBS, yes (vs. no)	2.375(2.109 to 2.674)	<0.001
Parkinson's Disease, yes (vs. no)	2.750 (1.620 to 4.669)	<0.001
Dementia, yes (vs. no)	5.679 (2.586 to 12.472)	<0.001
Schizophrenia, yes (vs. no)	5.435 (3.932 to 7.513)	<0.001
Substance abuse, yes (vs. no)	4.178 (1.960 to 8.908)	<0.001
Living alone, yes (vs. no)	1.608 (1.473 to 1.755)	<0.001

Abbreviations are as Table 1, CI, Confidence interval.
Covariates in the multivariable model included age, gender, body mass index, waist circumference, smoking status, married status, educational status, hypertension, diabetes mellitus, dyslipidemia, coronary artery disease, valvular heart disease, asthma, chronic obstructive pulmonary disease, osteoporosis, gout, gastroesophageal reflux disease, peptic ulcer, irritable bowel syndrome, Parkinson's Disease, dementia, schizophrenia and substance abuse.

Odds ratios for psychiatric morbidity by marital status

Because the presence or absence of living alone is related to marital status, we then performed a subgroup analysis, and divided the subjects into two groups according to marital status. As shown in Supplementary Table 3, the risk of psychiatric morbidity in the unmarried group was not affected by living alone (OR = 1.155, 95% CI = 0.990 to 1.348, $p = 0.067$), however the risk of psychiatric disorders in the married group was related to living alone (OR = 1.876, 95% CI = 1.692 to 2.081, $p < 0.001$). The results were similar when analyzing men and women separately (Supplementary Table 4). Moreover, married subjects who lived alone and divorce/separation (OR = 2.013, 95% CI = 1.763 to 2.299, $p < 0.001$) or widowing (OR = 1.750, 95% CI = 1.373 to 2.229, $p < 0.001$) were more likely to have psychiatric morbidity than those who were married and not living alone (Table 4 and Supplementary Table 5).

Discussion

This study is the largest population-based study to examine the association between living alone and psychiatric morbidity, and it showed a statistically significant association between them. We also found that this association was present in the subjects who were married, but not in those who were not married. In addition, married subjects who lived alone in concordance with divorce, separation, or the death of a spouse were associated with a higher risk of psychiatric morbidity.

Living alone has been associated with poor mental health conditions (32–36). Stahl, et al. (32) found that living alone was associated with elevated levels of depressive symptoms compared to living with a family member. Similar findings were

TABLE 4 Odds ratios for psychiatric morbidity by marital status.

Characteristics	No. of psychiatric morbidity cases/ no. of subjects (%)	Adjusted odds ratio (95% CI)	*p value*
All subjects, unmarried ($n = 16,542$)			
Living alone (-)	619/12,123 (5.1)	reference	–
Living alone (+)	259/4,419 (5.9)	1.155 (0.990 to 1.348)	0.067
All subjects, married ($n = 105,059$)			
Living alone (-)	4,066/99,650 (4.1)	reference	–
Living alone (+) and married	74/1,088 (6.8)	1.688(1.368 to 2.056)	<0.001
Living alone (+) and widowing	120/1,392 (8.6)	1.750 (1.373 to 2.229)	<0.001
Living alone (+) and divorce or separation	276/2,929 (9.4)	2.013 (1.763 to 2.299)	<0.001

CI, Confidence interval.
Covariates in the multivariable model included age, gender, body mass index, waist circumference, smoking status, educational status, hypertension, diabetes mellitus, dyslipidemia, coronary artery disease, valvular heart disease, asthma, chronic obstructive pulmonary disease, osteoporosis, gout, gastroesophageal reflux disease, peptic ulcer, irritable bowel syndrome, Parkinson's Disease, dementia, schizophrenia and substance abuse.

also noted in the elderly population (34). In a qualitative meta-analysis, Hu, et al. found that older people living alone had a higher risk of depression than those not living alone (33). Consistent with our results, the relationship between living alone and anxiety has also been discussed in previous research; for example, Hunt, et al. (35) and Yu, et al. (36) found that people living alone had a significantly higher risk of generalized anxiety disorder than those living with their families.

An interesting finding of this study is that living alone increased the risk of psychiatric morbidity in married subjects, but not in unmarried subjects. A previous study reported that the psychological well-being of divorced and widowed people was poorer than those who never married (37). Marital relationships can provide a sense of well-being and emotional support, producing mutual obligations and reinforcements between the two parties (38, 39). These relationships reduce vulnerability to psychological disorders. However, a change in this connection has been shown to significantly increase depressive symptoms (40). Thus, this might explain a higher likelihood of married people but living alone suffering from psychiatric disorders.

We also found that married subjects who lived alone and widowed had a 1.76-fold risk of having psychiatric morbidity compared to those who were married and not living alone. Widowhood has been known for being a catastrophic event with a negative impact on both physical and emotional well-being (41, 42). Various factors have influenced the degree of emotional response to spouse loss such as age, gender, length of widowhood, health condition, economic status, and living arrangements (43, 44). Srivastava, et al. (45) reported that the interaction between marital status and living arrangements on depression showed that widowed and living alone elderly were more likely to suffer from depression than those currently married and co-residing. The rates of depression were highest in widowed and living alone, followed by widowed and co-residing, currently married and co-residing, currently married and living alone (45). The negative psychological well–being of widowhood could be explained by the poor emotional and financial support that comes with spouse loss (46, 47).

Meanwhile, the relationship between living alone and lack of social support was also reported in COVID-19 related studies that resulted in higher risk of depression and anxiety (48, 49). The addition of widowed and separated status was revealed to be related to depression and poor quality of life due to loneliness (50). Poor psychological well-being has been linked to objective social isolation (51) and subjectively perceived social support, such as loneliness (52). Moreover, in a large nationally longitudinal study, Domènech-Abella, et al. (53) reported that both loneliness and social isolation affected the probability of suffering from depression and anxiety.

This is an important public health issue, because people suffered from psychiatric disorders are at increased risk of suicide, self-harm, and mortality (54–56). Thus, proper care and treatment are crucial to reduce mortality and extend life expectancy. Stahl, et al. (32) suggested that adults living alone need to have a better perception of neighborhood social quality. Having a good relationship with neighbors has been shown to relieve loneliness and depression by increasing the availability of social activities, receiving practical help from others, and making older people feel safer and more secure (57–59). Another study showed that leisure activities may moderate poor mental health in older adults living alone (60). Older adults living alone may have reduced physical activity and social interaction, and encouraging them to participate in leisure activities could increase their level of physical activity and social connection with others and affect positive emotional outcomes (60–62). Thus, people living alone tend to have fewer social interactions and activities and feel lonely and insecure (36).

Having a good relationship with neighbors or participating in leisure activities could reduce the risk of suicide, self-harm, and mortality.

Besides living alone, other parameters are also associated with psychiatric morbidity. Our results revealed that the subjects with chronic diseases, such as diabetes mellitus, cardiovascular, respiratory, orthopedic, gastrointestinal, or neurological diseases had a higher likelihood of psychiatric morbidity (63–66). Chaudhry, et al. (67) reported a prevalence of psychiatric morbidity among insulin-dependent patients of 18%, and that people with diabetes mellitus were twice as likely as the general population to suffer from psychiatric morbidity. Psychiatric morbidity is common in patients with coronary heart disease, and a previous study reported that 16% of patients assessed seven days after myocardial infarction had symptoms consistent with a major depressive episode (68, 69). With regards to the relationship between respiratory diseases and psychiatric morbidity, a study in India found that 44.8% of patients with respiratory illnesses had a mental illness compared with 24.3% of controls (70).

The relationship between psychiatric morbidity and chronic diseases could be attributed to patients' panic, pessimism, and emotional imbalance after diagnosis. From the aspect of biology, the hypothalamic adrenocortical axis could be induced by both depression and diabetes (67). Devolving psychiatric morbidity, hypertension, and cardiovascular diseases could be attributed to a lack of the central neurotransmitter serotonin (68, 71, 72). Thus, people with chronic diseases have an increased risk of psychiatric morbidity.

Although our study is the most extensive population-based study examining the relationship between living alone and psychiatric morbidity to date, several limitations should be acknowledged. First, the design of this study was cross-sectional, and thus determining the duration of psychiatric morbidity in the people living alone is difficult. Further prospective studies are needed to elucidate the causal effects of living alone on psychopathology. Second, we used self-report questionnaires to assess psychiatric morbidity. As psychiatric disorders remain a social stigma, some people may have hesitated to answer truthfully, and thus we may have underestimated the prevalence of psychiatric morbidity. Furthermore, we may have underestimated the role of certain comorbid conditions due to a lack of information. Third, we defined psychiatric morbidity as a GAD-2 score $\geqq$3, PHQ-2 score $\geqq$3, or self-reported depression to include both depression and anxiety as the main focus of this study. However, we lacked data on self-reported anxiety. The initial questionnaire design of our study did not cover self-reported anxiety, so we used the GAD-2 score $\geqq$3 to represent anxiety groups. Such an approach has been validated in other studies (73, 74). Fourth, we did not include some factors that may affect mental health, such as income, work, socioeconomic status, physical activity, and family support (75–77). This may have led to an underestimation of the risk of psychiatric morbidity and the association with living alone. Finally, only 16,582 participants completed the PHQ-2 and GAD-2, resulting in a lot of missing data. However, both PHQ-2 and GAD-2 are quantitative indicators which can represent the current status of participants, and by combining self-reported depression, PHQ-2 and GAD-2 can provide a holistic understanding of living alone and mental disorders.

Conclusion

Our findings suggest that living alone is a risk factor for psychiatric morbidity, especially in those who are married. This highlights the importance of improving the care system for married persons living alone in concordance with divorce, separation or the death of a spouse to protect their physical and mental health. Further well-designed prospective studies are needed to investigate the causal effects of living alone on psychopathology.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: the data underlying this study is from the Taiwan Biobank. Due to restrictions placed on the data by the Personal Information Protection Act of Taiwan, the minimal data set cannot be made publicly available. Data may be available upon request to interested researchers. Requests to access these datasets should be directed to S-CC, scarchenone@yahoo.com.tw.

Ethics statement

The studies involving human participants were reviewed and approved by Institutional Review Board of Kaohsiung Medical University Hospital (KMUHIRB-E(I)-20210058). The patients/participants provided their written informed consent to participate in this study.

Author contributions

Conceptualization, methodology, formal analysis, investigation, data curation, writing—review and editing, and visualization: J-HG and J-IL. Software and project administration: J-HG. Validation, supervision, and funding acquisition: S-CC. Resources: J-HG and S-CC. Writing—original draft preparation: T-YC. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1054615/full#supplementary-material

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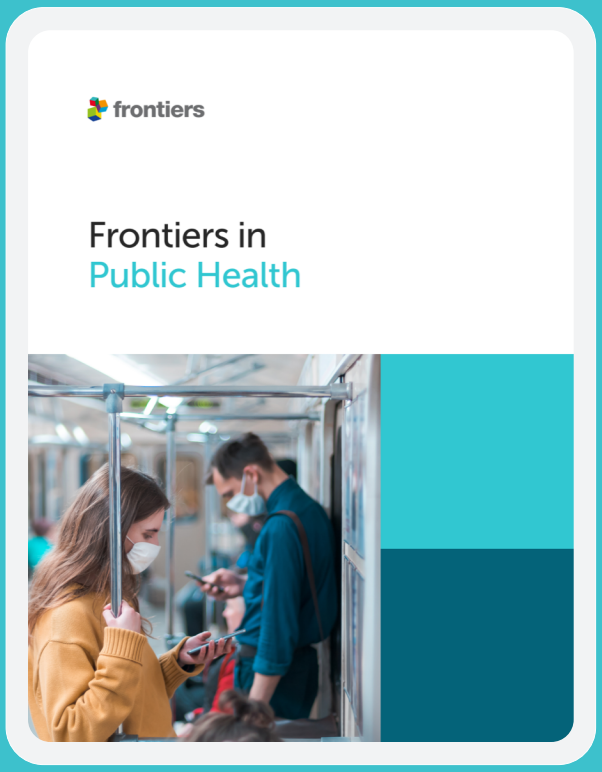

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