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Mental health, social media, and the metaverse

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Mental health, social media, and the metaverse

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Commonly reported negative experiences on social media are associated with poor mental health and well-being among adolescents: results from the "LifeOnSoMe"-study

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Introduction: Cyberbullying has been extensively studied and is associated with adverse mental health outcomes in adolescents. However, adolescents may also experience a range of other negative experiences, such as name-calling, threats, exclusion, and unwanted attention or contact from others. Few studies have investigated how adolescents' mental health is affected by these relatively common and less severe types of negative experiences on social media (SOME). To assess the association between mental health outcomes and two aspects of negative experiences on SOME; unwanted attention and negative acts and exclusion.

Methods: This study is based on a survey conducted in 2020/21 consisting of 3,253 Norwegian adolescents (56% female, M_{age}=17 years). Eight statements about negative experiences on SOME were asked and combined into two composite measures: "Unwanted attention from others" and "Negative acts and exclusion." Dependent variables in regression models were symptoms of anxiety, symptoms of depression, and mental well-being. Covariates in all models included age, gender, subjective socioeconomic status, and amount of SOME-use.

Results: Both "negative acts and exclusion" and "unwanted attention from others" on SOME were consistently positively associated with self-reported symptoms of depression and anxiety, and negatively associated with mental well-being in both crude and adjusted analysis.

Discussion: The results are indicative of an important relationship between experiencing negative events on SOME, even presumably less severe events, and worse mental health and well-being. Future research should extricate the potential causal relationship between negative experiences on SOME and mental health, as well as exploring potential precipitating and intermediating factors.

KEYWORDS
social media, adolescents, mental health, negative experiences, cybervictimization

1. Introduction

Social media is widely used and constitutes an important aspect of everyday life, particularly for adolescents (1). The extensive use of social media among adolescents has caused concern about potentially negative effects on adolescents' mental health and well-being (2). Although early research investigated the effect of overall amount of social media use on adolescents' well-being, the current consensus is that social media use entails a wide range of activities and experiences that must be considered separately (3, 4).

One concern with social media platforms is that they might extend the areas where one can have negative experiences. The pervasiveness of smartphone ownership and social media use has transformed when and where relational aggression may occur (5), and cyberbullying has been extensively studied (6, 7). Bullying is a specific form of peer aggression that is repeated, intentional, and with the purpose of harming the victim, and where there is a power imbalance in favor of the perpetrator (8). Although social media can create new opportunities for bullying (2), traditional bullying seems to be more prevalent than cyberbullying (9). The association between bullying and negative mental health outcomes is well-established [e.g. (10–12),], and cyberbullying is also associated with negative mental health outcomes (5, 13–15). In fact, a meta-analysis showed that cyberbullying is more strongly related to suicidal ideation than traditional bullying (16). This might be because cyberbullying can include anonymity, a larger audience, and difficulty keeping distance from the bullying (17). In addition to experiences classified as bullying (i.e., meet the Olweus criteria), adolescents can have a range of other negative experiences. These include name-calling, threats, and exclusion, and are often termed cybervictimization. This term is less stringent than cyberbullying, and has been defined as "the broad range of intentional acts of aggression and victimization that occur through social media" [(18), p. 298].

Virtual communities that enable adolescents to build a sense of belonging can also exclude and ostracize many others. The phenomenon of cyberostracism (19, 20), where individuals are ignored or excluded during online interactions, leads to adolescents feeling angry and aggressive (21), and even victimized leading to feelings of unworthiness and depression (22). In a recent study of cyberostracism and well-being in a Chinese university context (23), cyberostracism undermined their well-being and their need satisfaction, which is the essential source for facilitating a fully functioning state (24). These deleterious effects of cyberostracism pose a threat both to the adolescent and to society by increasing negative emotional, behavioral, and anti-social responses (25).

In a study including almost 25,000 adolescents in Spain and Ecuador, Rodríguez-Hidalgo et al. (26) explored the prevalence of cybervictimization, and found that 9% experienced one form of cybervictimization at least once or twice a month. A study of lifetime prevalence among adolescents found that 59% had experienced at least one type of relational aggression on social media, such as the spreading of false rumors or name calling (27). In a Norwegian survey of adolescents, 31% reported that others had written nasty comments to them online, during gaming, or on social media in the past year (28). Furthermore, 26% reported that someone had been mean or bullied them, 24% that they had been excluded or prevented from participating in an online group, while 15% had been threatened, and 14% that someone had posted a photo of them that made them feel sad or angry. There were gender differences in these negative online experiences. Bullying, nasty comments, and threats were more common among 15–18 year old males than females (28). Conversely, more females than males had experienced being excluded from online groups or that someone had posted a photo of them that made them sad or angry.

Other negative interactions on social media can include unwanted attention or contact from others, as one becomes approachable to a wide range of people. A Norwegian report showed that three out of 10 13–18 year-olds have received sexual comments in the past year, increasing from 19% among 13–14 year-olds to 42% among 17–18 year-olds (28). While some found such comments exciting, over one third of females found it uncomfortable and half had blocked the person who had made the comment.

While cyberbullying has received extensive attention in research (2, 6, 7), there has been little focus on subjective negative experiences that less readily classify as bullying. Our own study found that low socioeconomic status was associated with more negative experiences on social media in a sample of adolescents (29). Another study using the same dataset found that both the amount of negative experiences and the number of different negative experiences was associated with increased alcohol use and indications of potential alcohol-related problems (30). A study by Rosenthal and colleagues found an association between different negative experiences on Facebook and symptoms of depression, which was consistent after controlling for socioeconomic status (31). Due to the pervasive use of social media among adolescents, investigating the relationship between these types of negative experiences on social media and mental health and well-being is warranted. In the present study, we assessed the association between mental health outcomes and two aspects of negative experiences on social media, namely unwanted attention and negative acts and exclusion. Specifically, we hypothesized positive associations between negative experiences on social media and symptoms of anxiety and depression, and a negative association with mental well-being. Based on previous research, we included age, gender, subjective socioeconomic status, and amount of social media use as covariates.

2. Methods

2.1. Sample

The present study employed cross-sectional data from the "LifeOnSoMe"-study, which recruited all public high school students in the municipality of Bergen (Norway) aged at least 16 years. One of the objectives of the "LifeOnSoMe"-study was to collect questionnaire

data to shed light on adolescents' use of social media beyond mere amount of use. Briefly, the study included several aspects of social media use, including motivations underlying use, positive and negative experiences related to use, views and opinions about their own and others use of social media, as well as how and when they use social media. Another objective of the study was to investigate the potential relationship between different aspects of social media use and other important areas in adolescent's lives, including but not limited to mental health and well-being.

The data was collected in September and October 2020 and in June to September 2021, with a participation rate of 53 and 35.4%, respectively. The data collection was web-based, and the high school students received a survey-specific web address containing written online information about the study as well as the possibility to consent to participate. The study was approved by the regional ethics committee and was in agreement with the General Data Protection Regulation (See also "Ethics" below for more information). The total number of participants eligible for the present study was $N = 3,253$.

2.2. Exposure: negative experiences on social media

Eight statements regarding negative experiences on social media were asked, each with responses ranging from "Never" to "Very often." The statements did not have a specified timeframe. The statements are derived from analyses of focus group interviews of adolescents regarding social media use and mental health and well-being (32). In brief, the focus group interviews investigated the perspectives and insights of adolescents regarding the positive and negative associations between social media use and their mental health and well-being. The participants were recruited from two senior high schools, and three main themes are presented in Hjetland et al.' (32) paper: "Interpersonal consequences of social media," "personal consequences of social media," and "motivations affecting social media use," each with a set of sub-themes. Afterward, the qualitative data were used to develop a set of statements reflecting the content and meaning of the described themes to be used in questionnaires. The statements related to negative experiences on social media and the corresponding response distributions are presented in Table 1.

Based on previously published findings from the same dataset (29), the variables 1, 3, and 4 were combined as a composite measure of "Unwanted attention from others" (Cronbach's alpha; 0.81), and the remaining five variables were combined as a composite measure of "Negative acts and exclusion" (Cronbach's alpha; 0.84). Lastly, we also estimated the number of endorsed items (i.e., more than "never") ranging from 0 to 8. This count variable was named "Number of negative experiences."

2.3. Outcomes: mental health and well-being

2.3.1. Symptoms of anxiety

Anxiety was measured by the questionnaire General Anxiety Disorder 7 [GAD-7; (33)]. GAD-7 consists of seven questions regarding symptoms of general anxiety scored from 1 (not at all) to 4 (almost every day). The questionnaire can be used as a continuous

TABLE 1 Negative experiences on social media.

Statements	*N* =3,253
#1: I get unwanted attention from strangers	
Never	33.7%
Seldom	33.4%
Sometimes	23.6%
Often	6.7%
Very often	2.7%
#2: Others share pictures/videos of me against my will	
Never	59.7%
Seldom	30.5%
Sometimes	8.1%
Often	0.9%
Very often	0.8%
#3: I receive unwanted nude pictures/ sexualised content	
Never	53.8%
Seldom	22.5%
Sometimes	17.0%
Often	4.3%
Very often	2.4%
#4: I am asked to send nude pictures/ sexualised content	
Never	60.3%
Seldom	20.0%
Sometimes	13.3%
Often	4.2%
Very often	2.2%
#5: I get negative comments on what I post	
Never	84.5%
Seldom	10.8%
Sometimes	3.8%
Often	0.5%
Very often	0.3%
#6: I receive unpleasant or hurtful messages	
Never	74.7%
Seldom	16.8%
Sometimes	7.0%
Often	0.7%
Very often	0.7%
#7: Others say/post negative things about me	
Never	74.7%
Seldom	16.6%

(Continued)

TABLE 1 (Continued)

Statements	*N* =3,253
Sometimes	7.0%
Often	1.1%
Very often	0.6%
#8: I feel excluded from groups/chats	
Never	62.0%
Seldom	24.5%
Sometimes	10.0%
Often	2.1%
Very often	1.4%

Statements and response distribution (%).

measure [total score, ranging from 0 to 21 in this study (28 maximum)] or as a dichotomous variable with a cut-off of 10 to define case-level. Cronbach's alpha was 0.89 in the present sample. In the present study GAD-7 was used both as a continuous and a dichotomous variable (see section 3).

2.3.2. Symptoms of depression

Depression was measured by the Short Mood and Feelings Questionnaire [SMFQ; (34)]. SMFQ consists of 13 statements related to symptoms of depression with the following response options 0 (not true), 1 (sometimes true), and 2 (correct). The questionnaire can be used as a continuous measure (total score, ranging from 0 to 26) or as a dichotomous variable with a cut-off at the 90th percentile to define case-level. Cronbach's alpha was 0.91 in the present sample. In the present study, SMFQ was used both as a continuous and a dichotomous variable (see section 3).

2.3.3. Mental well-being

Mental well-being was measured using the Warwick–Edinburgh Well-being Scale (35). WEMWBS consists of 14 statements related to mental well-being and quality of life scored from 1 (not at all) to 5 (all the time). WEMWBS can be used as a continuous measure (total score, ranging from 5 to 70), and as a dichotomous measure with the median as the cut-off point as recommended by those who developed the scale and empirical findings. Cronbach's alpha was 0.92 in the present sample. In the present study, WEMWBS was used both as a continuous and a dichotomous variable (see section 3).

2.4. Covariates

2.4.1. Age and gender

Age and gender were registered by self-report. Gender included a non-binary option, but only 37 participants ticked this option. Due to the small number, they were excluded from further analyses in the present study.

2.4.2. Subjective socioeconomic status

The participants could indicate their subjective socioeconomic status (S-SES) by responding to the question "How well off do you consider your own family to be compared to others?" Response options ranged from 0 ("Very poor") to 10 ("Very well off"). The distribution of the S-SES variable was right-skewed with mean of 7.2 (standard deviation 1.8). In the present study, a tripartite variable was created differentiating between low SES (scores 0–4), medium SES (scores 5–7), and high SES (scores 8–10).

2.4.3. Amount of social media use

Two questions regarding amount of social media use were included:

1. "How often do you use social media?" with response options ranging from "Almost never" to "Almost constantly." For the purposes of the present study, we differentiated between "Daily or less," "Many times a day," and "Almost constantly."
2. "The days you use social media, approximately how much time do you spend per day?" with response options ranging from "Less than 30 min" to "More than 5 h." In the present study, we differentiated between "Less than 2 h," "2–4 h," "> 4–5 h," and "More than 5 h."

3. Statistical analysis

First, results from descriptive analyses of the included variables are presented in Table 2, using mean and standard deviation and median and interquartile range for continuous data and frequency and proportion for categorical data. In separate logistic regression models, the three outcomes (case-level depression, case-level anxiety, and the median split of mental well-being) were sequentially regressed on the variables "negative acts and exclusion," "unwanted attention from others," and "number of negative experiences." The results are presented as odds ratios with 95% confidence intervals in Table 3. In addition to the results from the logistic regression models, we also present the *E*-values for each model in Table 3. The E-value gives an estimate of the amount of unmeasured confounding needed to be present in order to fully explain away the observed associations, conditional on the measured covariates (16). As such, the *E*-values gives a numerical value to the liminal additional confounding necessary to reach non-significance. The associations between negative experiences on social media and symptoms of depression, symptoms of anxiety and mental well-being score were estimated using linear regression models across the variables "negative acts and exclusion" and "unwanted attention from others" and the results are presented in Table 4. The three outcomes were converted to *z*-scores, to obtain *y*-standardized regression coefficients. Finally, the association between each of the separate variables related to negative experiences and case-level depression, case-level anxiety, and mental well-being (median split) was estimated using logistic regression models and presented in Figure 1. All regression models included age, gender, subjective socioeconomic status, and amount of social media use as covariates. Data handling and analyses were performed in Stata version 15, and statistical analyses was performed both in Stata version 15 (36) and in R (37). Tables were produced using the "gtsummary" package in R (38). *E*-values were calculated using the *E*-value command available for Stata (39).

4. Results

Summary statistics of the included variables are presented in Table 2. The median age was 17 years, and 56% of the sample were female. Just over half of the sample reported medium socioeconomic status. Half of the sample reported using social media many times a day, and 70% reported using social media at least 2 h a day. Almost three out of four (74.5%) reported at least one of the negative experiences seldomly or more frequently, and the median number of different negative experiences was 3.

TABLE 2 Summary statistics of included variables.

Characteristic	*N* =3,253[1]
Age	
16	593 (18%)
17	1,556 (48%)
18	894 (27%)
19+	210 (6.5%)
Gender	
Boys	1,418 (44%)
Girls	1,835 (56%)
Subjective socioeconomic status	
Low (0–4)	209 (6.4%)
Medium (5–7)	1,704 (52%)
High (8–10)	1,340 (41%)
How often do you use SoMe?	
Every day or less	771 (24%)
Many times a day	1,630 (50%)
Almost constantly	852 (26%)
Time spent on SoMe?	
Less than 2 h	969 (30%)
2–4 h	1,228 (38%)
>4–5 h	587 (18%)
More than 5 h	469 (14%)
Number of negative experiences on SoMe	3.00 (1.00, 5.00)
Negative acts and exclusion, SoMe	1.41 (0.57)
Unwanted attention from others, SoMe	1.86 (0.88)
Score on WEMWBS	48 (10)
Score on GAD	5.0 (2.0, 8.0)
Score on SMFQ	5 (3, 10)

[1]*n* (%); Median (IQR); Mean (SD).

Reporting at least one of the negative experiences at least seldomly was associated with increased odds for case-level anxiety [Odds ratio (OR) 2.16 (95% CI: 1.74–2.69), $p < 0.001$] and case-level depression [OR 2.26 (1.67–3.04), $p < 0.001$], and lower odds for above median mental well-being [OR 0.57 (0.49–0.66), $p < 0.001$].

All of the three main measures of negative experiences on social media were positively associated with case-level depression (ORs ranging from 1.25 to 2.29) and case-level anxiety (ORs ranging from 1.19 to 1.91). For mental well-being, negative associations were observed (ORs ranging from 0.85 to 0.49). The *E*-values ranged from 1.39 to 4.01. The highest *E*-value was observed for the association between "negative acts and exclusion" and case-level depression, while the lowest *E*-value was observed for number of negative experiences and the median-split of mental well-being. See Table 3 for further details.

Both "negative acts and exclusion" and "unwanted attention from others" on social media were positively associated with symptoms of depression [0.46 standard deviations (SD) and 0.25 SD, respectively] and anxiety [0.36 and 0.24 SD, respectively], and negatively associated with score on mental well-being (−0.37 and −13SD, respectively). The strength of the observed association (i.e., "effect size") ranged between small to medium. See Table 4 for further details.

Results from separate logistic regression models for all the specific negative experiences on social media are presented in Figure 1. Across all the variables gauging negative experiences on social media, positive association with case-level depression and anxiety were observed, while a negative association was observed with mental well-being (median split). All estimates were statistically significantly different from the reference category "never," except for case-level depression and reporting "receive unwanted nude pictures/sexualized content" seldom, and case-level anxiety and reporting "unwanted attention from strangers" seldom. Results from crude logistic and linear regression models yielded similar results to the presented findings (data not shown).

TABLE 3 Association between negative experiences and case-level depression, case-level anxiety, and well-being (median split).

	Case-level depression				Case-level anxiety				Well-being, median split			
Characteristic	OR[1]	95% CI[1]	*p* value	*E*-value	OR[1]	95% CI[1]	*p* value	*E*-value	OR[1]	95% CI[1]	*p* value	*E*-value
Negative acts and exclusion, SoMe	2.29	1.93, 2.72	<0.001	4.01	1.91	1.65, 2.20	<0.001	2.11	0.49	0.42, 0.57	<0.001	2.21
Unwanted attention from others, SoMe	1.74	1.54, 1.98	<0.001	2.88	1.56	1.41, 1.73	<0.001	1.81	0.80	0.73, 0.88	<0.001	1.48
Number of negative experiences on SoMe	1.25	1.19, 1.31	<0.001	1.81	1.19	1.15, 1.24	<0.001	1.41	0.85	0.83, 0.88	<0.001	1.39

[1]OR, odds ratio; CI, confidence interval.
Logistic regression models, adjusted for age and gender, socioeconomic status, and amount of SoMe-use.

TABLE 4 Association between negative experiences and symptoms of depresssion, symptoms of anxiety, and well-being score.

	Depression symptoms			Anxiety symptoms			Well-being, score		
Characteristic	Beta	95% CI[1]	*p* value	Beta	95% CI[1]	*p* value	Beta	95% CI[1]	*p* value
Negative acts and exclusion, SoMe	0.46	0.40, 0.51	<0.001	0.36	0.31, 0.42	<0.001	−0.37	−0.43, −0.31	<0.001
Unwanted attention from others, SoMe	0.25	0.21, 0.29	<0.001	0.24	0.20, 0.28	<0.001	−0.13	−0.17, −0.09	<0.001

[1]CI, confidence interval.
Dependent variables Z-scored, beta equivalent to standard deviation. Linear regression models, adjusted for age and gender, socioeconomic status, and amount of SoMe-use.

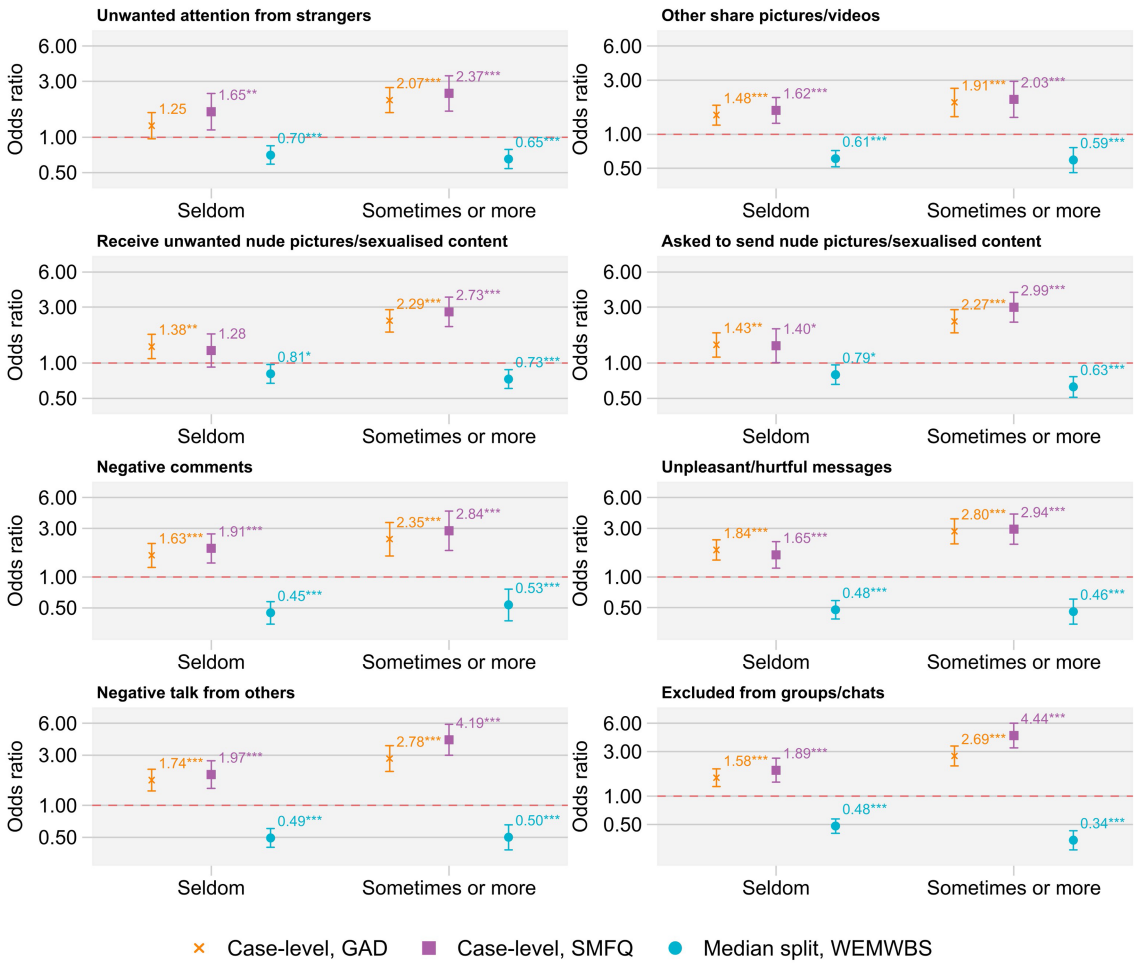

FIGURE 1
Association between mental health and well-being, and negative experiences on SoMe. Logistic regression models. Adjusted for age and gender, socioeconomic status, and amount of SoMe-use. Pairwise deletion.

5. Discussion

In the present study, we examined the potential association between a range of common negative experiences on social media and mental health and well-being. Our results indicate consistent positive associations between both "negative acts and exclusion" and "unwanted attention from others" on social media and self-reported symptoms of depression and anxiety. There were also consistent negative associations between both types of negative experiences and mental well-being. The same pattern was seen for the number of different negative experiences on social media and mental health and well-being. All the investigated associations were robust to adjustments for age, gender, socioeconomic status, as well as amount of social media use. The estimates for what levels of unmeasured

confounding were needed to explain away our observed associations varied from small to strong. For the association with the highest point estimate, between "negative acts and exclusion" and case-level depression, the observed odds ratio of 2.29 could be explained away by an unmeasured confounder that was associated with both the exposure and the outcome by an odds ratio of 4.01-fold each, above and beyond the measured confounders (40). Weaker confounding could not do so. Although the other *E*-values were lower, our overall consistent findings can be considered robust to any reasonably expected impact of unmeasured confounding. Overall, the presented results are indicative of an important relationship between experiencing negative events on social media, even presumably less severe events, and worse mental health and well-being.

Our findings are in line with a previous study investigating negative experiences on Facebook and association with depressive symptoms among young adults (31). The paper by Rosenthal and colleagues included similar experiences to what we studied, such as "meanness" and "unwanted contact." They also found that all the included negative experiences were related to depressive symptoms. Interestingly, they found that past year negative experiences was less strongly associated with depressive symptoms compared to lifetime negative experiences, which the authors interpret as being an indication that experiencing these kinds of events in adolescence is more distressing than in adulthood. Similarly, our findings also support the finding from Niu and colleagues that there is a positive correlation between cyber-ostracism and symptoms of depression among adolescents aged 12–18 years (22). Taken together, the evidence available indicates that the day-to-day interactions and events on social media have a real-life impact on its users (22).

5.1. Strengths and limitations

The present study holds several strengths. First, the items related to negative experiences on social media cover many different aspects and are derived from focus group interviews with adolescents about their motivations, perspectives, and experiences related to the use of social media (32). It is therefore reasonable to believe that this ensures relevance and a high ecological validity. Second, the outcomes included are widely used and validated age-appropriate measures of potential mental health problems and mental well-being. Third, the robust sample size allowed for inclusion of potentially important confounders, and we also estimated the amount of unmeasured confounding needed to render the associations non-significant using the E-value approach (40). Fourth, the study used a broad definition of social media, and was not restricted to one or a few popular platforms.

Several limitations also need to be noted. First, the study is cross-sectional, which limits our ability to draw inferences about directionally. Second, although a range of different negative experiences on social media are covered, the list of experiences is not exhaustive, and it is quite possible that other commonly occurring experiences are also associated with mental health outcomes. Third, although we asked about how often they have lived through the listed experiences (ranging from "never" to "very often"), we did not provide any timeframe for them to consider. As such, the answers given could in theory be life-time experiences. However, due to recall bias, it is more likely that they would remember more recent experiences or experiences which had a greater impact on them (e.g., particularly more emotionally upsetting events). Relatedly, we did not include any measure of how the experiences impacted them. Fourth, we only included symptoms of anxiety and depression, as well as mental well-being as outcomes in our study. Thus, the potential relation between negative experiences on social media and other important aspects of mental health is not covered in the present study. Fifth, the participation rate was less than optimal, potentially decreasing the generalizability of our findings. The participation rate may also bias the reported descriptive statistics but is more unlikely to have substantially biased the reported associations (41). Lastly, the adolescents included are aged 16+, and the findings reported are not necessarily valid for other age groups such as younger adolescents or young adults.

5.2. Implications and future research

The findings from the present study indicate that negative experiences on social media are relatively common, as almost three out of four reported at least one of the included negative experiences seldomly or more frequently. Our findings also consistently indicate a relationship between these negative experiences and mental health problems and mental well-being. The combination of a relatively high prevalence of these experiences and the consistent associations found is noteworthy. Also, our findings are robust considering our estimate of the impact of unmeasured confounding. That is, it is unlikely that all of our reported associations would be rendered non-significant by introducing additional co-variates. Given our results, it is reasonable to surmise that the impact of negative experiences on social media on mental health is of public health relevance and should be addressed accordingly. Increased attention should be given not only to severe and uncommon negative experiences on social media, but also to more commonly reported negative experiences such as social exclusion and negative feedback/backbiting. A previous study has for instance shown that common life events/difficulties such as interpersonal difficulties in general are associated with mental health problems (42). The authors of that paper recommended—as do we—that adolescents should be helped by increasing their coping skills and resilience to manage various kinds of adversities they are likely to face. This notion is further supported by findings that resilience and social support potentially play a pertinent mediating role in the observed relationship between negative life events and quality of life among adolescents (43). Furthermore, specifically in relation to negative experiences on social media, there is a need to increase social media literacy among adolescents and parents as well as increasing engagement from parents and teachers regarding the lives adolescents live on social media. The latter recommendation may facilitate communication and increase awareness regarding how social media experiences, both positive and negative, affect the day-to-day mood and behavior of adolescents. If not, the negative repercussions of even presumably less severe but commonly experienced negative events could be longstanding and persist into later stages of development.

Finding ways to strengthening the potentially positive aspects of social media use, such as socializing and interacting with peers should also be emphasized in future research and in the development of intervention programs related to mental health among adolescents. Our own research has for instance found that

social media can serve as an arena for social support among adolescents, and that social support instigated in digital settings is positively related to mental health and well-being (44). As such, health-promoting interventions aimed at increasing both social media literacy and prosocial interaction on social media may be beneficial also in relation to negative experiences on social media. It is our view that it is unlikely to fully safeguard oneself from negative experiences on social media. We therefore believe that interventions specifically targeting negative experiences in tandem with more general health-promoting principles would hold the most promise.

Regarding future research, several aspects related to our findings need to be addressed. As with all cross-sectional studies, we are not able to ascertain potential causality between negative experiences on social media and mental health. Future research should employ longitudinal designs to investigate the putative causal relationship between the exposures and mental health. While it is likely that the negative experiences examined in the present study influence mental health adversely, it is also possible that poor mental health elicits social media use and interactions with others on social media that increases the likelihood of negative experiences. By extension, this can serve as the start of a vicious cycle where both negative experiences and certain mental health problems fuel each other to the detriment of the individuals in question. Future research should also aim to investigate potential intermediate factors potentially mitigating the relationships reported here. There is also a need to better understand the plethora of features and functionality of different social media platforms to shed light on how they may facilitate, and even encourage, negative and harmful behavior and social interactions. Lastly, there is also a need to investigate the role of individual differences and developmental trajectories to shed light on the dynamics of the associations in a longer-term perspective.

6. Conclusion

In the present study, we found consistent associations between a range of commonly reported negative experiences on social media and symptoms of anxiety and depression as well as reduced mental well-being. Taken together with previous findings, our findings point to a potentially important public health issue, which needs to be addressed. Health-promoting intervention programs aimed at strengthening social media literacy and prosocial interaction on social media may be one way to specifically prevent negative experiences. In addition, a strengthening of the adolescents' resilience in the face of adversity would probably also be beneficial. Future research should try to extricate the potential causal relationship between negative experiences on social media and mental health, as well as exploring potential precipitating and intermediate factors.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: explicit consent from the participants is required by the Norwegian Health research legislation and the Norwegian Ethics committees in order to transfer health research data outside of Norway. Ethics approval for this study was also dependent on storing the research data on secure storage facilities located at the Norwegian Institute of Public Health, which prevents the authors from providing the data as supplementary information. Requests to access these datasets should be directed to jens.christoffer.skogen@fhi.no.

Ethics statement

This study involving human participants were reviewed and approved by Regional Ethics Committee (REK) in Norway (REK#65611). Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

JS: conceptualization, formal analysis, and writing and editing all drafts. AA and TF: review and editing, feedback on analytical approach, and literature review. PR: review and editing and literature review. GB: review and editing and feedback on analytical approach. GH: conceptualization, review and editing, feedback on analytical approach, and literature review. All authors contributed to the article and approved the submitted version.

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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

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The role of boredom proneness and self-control in the association between anxiety and smartphone addiction among college students: a multiple mediation model

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Background: Smartphone addiction has been found to be a widespread public health issue, especially among youth. Previous studies reported a significant association between anxiety and smartphone addiction, but the underlying mechanism in this relationship is unclear. The purpose of this study was to investigate the mediating roles of boredom proneness and self-control in the relationship between anxiety and smartphone addiction.

Methods: Self-reported measures of anxiety, boredom proneness, self-control and smartphone addiction were administered to 1,526 Chinese college students.

Results: Smartphone addiction scores varied between 10 and 60 with an average of 30.89 ± 10.57 points. Anxiety had a direct and positive effect on smartphone addiction (effect = 0.18, 95% CI = 0.11–0.25), and an indirect effect on smartphone addiction through boredom proneness (effect = 0.10, 95% CI = 0.06–0.15) and self-control (effect = 0.16, 95% CI = 0.13–0.20). Boredom proneness and self-control sequentially mediated the relationship between anxiety and smartphone addiction (effect = 0.12, 95% CI = 0.10–0.15).

Conclusion: Anxiety is positively associated with smartphone addiction, and boredom proneness and self-control are important mediators in this relationship. Strengthening self-control and mitigating boredom could prevent smartphone addiction in anxious college students.

KEYWORDS

anxiety, boredom proneness, self-control, smartphone addiction, multiple mediating effects

Introduction

Today, smartphones offer great conveniences in the lives of their users because of their multi-dimensional capacity, which integrates several functions such as entertainment, virtual social communication, access to information, and online education (1). However, the overuse of smartphones and the accompanying psychological symptoms can lead to a form of behavioural addiction referred to as smartphone addiction (2). Smartphone addiction among adolescents and adults has been found to be a widespread public health issue and has a negative effect on the health and daily life of students (3–5). Previous studies have reported that addictive smartphone use can cause physical problems related to the function of the immune system through exposure

to wireless waves and rays (6), and results in social and psychological issues, such as blocking face-to-face communication and sleep disturbances (5, 7, 8). Furthermore, the excessive and uncontrolled dependency of students on smartphones can negatively affect their academic performance and quality of life (1, 3, 9). Therefore, drawing public attention to smartphone addiction among college students and exploring the underlying mechanisms of addiction are urgently needed.

Many studies have verified that smartphone addiction results from a combination of personal, environmental, social, and emotional factors, among which anxiety is a crucial factor. Anxiety, characterised by unpleasant feelings of apprehension and fear, is defined as a temporary, tense state resulting from anticipating danger, something unknown, or strange (10, 11). Anxiety among college students is a common mental health issue, and has been identified a moderate to high prevalence (10, 12–14). Moreover, anxiety can make individuals vulnerable to excessive use of smartphones and increase the risk of phone addiction (15–17). To date, studies have focussed on exploring the relationship between anxiety and phone addiction; however, the underlying mechanisms in this relationship have not been adequately investigated, and existing studies have done little to address how some of the influential factors between the two variables play roles in this mechanism. Therefore, this study further examines this relationship, its underlying mechanisms, and the mediating effects of boredom proneness and self-control in the link between anxiety and smartphone addiction.

Boredom proneness, a trait-based tendency to experience boredom states in various environments, arises from the perception of meaningless or uninteresting situations (18). When people experience anxiety, they have negative affectivity, which can in turn render everything insignificant and monotonous (19). Therefore, it is plausible that individuals with anxiety are likely to experience boredom proneness as they may not reorganise their time to engage in more exciting or satisfying activities and may perceive achievement-related activities as lacking value (20). Anxious individuals, compared with non-anxious ones, are usually more vulnerable to experiencing higher levels of boredom (19, 21). Therefore, we propose that anxiety may be positively associated with boredom proneness.

People with high boredom proneness tend to have impaired attention and impulse control (22). They will have decreased attention in significant tasks, and instead engage in enjoyable activities, using networked mobile devices to alleviate the boredom (23). Moreover, individuals with boredom proneness have an increased likelihood of problematic smartphone use or smartphone addiction (19, 24). Furthermore, one study confirmed that boredom proneness mediated the relationship between anxiety and problematic smartphone use (21). These findings indicate that boredom proneness may be positively related to smartphone addiction. Hence, we proposed Hypothesis 1: boredom proneness mediates the relationship between anxiety and smartphone addiction.

Self-control largely refers to the ability to inhibit maladaptive or undesirable behavioural tendencies, modify inner responses, and bring thoughts and actions in line with personal values or goals and social expectations or standards (25). Based on the limited resource of self-control theory, good self-control requires cognitive resources and mental energy, both of which are limited. Resource-consuming responses, such as emotion or impulse control, may lead to deficiencies in self-control, which in turn results in problematic behaviours (24). Therefore, people with anxiety might devote self-regulatory resources to manage feelings of fear and modify anxious feelings, thoughts and behaviours. They may also have an additional burden on their self-control ability (26). According to these findings, we propose that anxiety may be positively related to self-control.

Previous researches have shown that the decline in self-control is one of the critical aspects of addictive behaviour among individuals (4, 27). Self-control theory is influential in explaining addictive behaviour problems; high levels of self-control enable greater effectiveness in the capacity to cope with negative thoughts and control improper behaviours (28). When individuals have a low degree of self-control, they may fail to consider the potential adverse consequences of their actions and may have difficulty controlling their behaviours (25). In addition, individuals with a low degree of self-control are dominated largely by short-term goals and immediate gratification (29). In particular, the use of smartphones in particular diverts the attention from negative emotions and involves the immediate pursuit of pleasure (30). According to these findings, we, therefore, proposed Hypothesis 2: self-control mediates the relationship between anxiety and smartphone addiction.

According to the limited resources of self-control theory, individuals with boredom proneness would exert effort to seek interesting activities to ameliorate meaninglessness or vapidity, which decreases self-regulatory resources. The depletion of self-control resources will reduce the ability to exert self-control (31). Many studies have reported that boredom proneness is a key predictor of low self-control, and that self-control mediates the link between emotional factors and problematic or addictive behaviours (24, 29, 32). However, there has been a lack of research investigating the serial mediating role of boredom proneness and self-control in the relationship between anxiety and smartphone addiction among college students. As previous studies have suggested a negative relationship between boredom proneness and self-control, we proposed Hypothesis 3: boredom proneness and self-control sequentially mediate the association between anxiety and smartphone addiction.

To obtain further insights into the relationship between anxiety and smartphone addiction, this study adopted a chain mediating effect model capable of simultaneously exploring multiple mediation pathways of the effects of anxiety on smartphone addiction. Under the chain mediating model, anxiety first gives rise to greater boredom proneness, which results in lower self-control, allowing anxiety to be treated as a predictor of smartphone addiction.

Methods

Participants and procedure

This study was a cross-sectional survey conducted at Binzhou Medical University in Yantai, Shandong Province, located in the eastern coastal region of China. We adopted a convenience sampling method including all college students studying at Binzhou Medical University from October to November 2022. An online survey was conducted to reduce in-person interactions. The self-administered questionnaire was distributed *via* the Wenjuanxing platform,[1] a professional online survey tool widely used in China (13). Written informed consent to participate was obtained from the schools and teachers, and participants were

1 https://www.wjx.cn/

invited to participate anonymously in the online self-report surveys. The independence, authenticity and integral nature of all answers and the confidentiality of the information collected were emphasised to all participants. The inclusion criteria are: (1) Volunteered to participate in the study; (2) Enrolled in Binzhou Medical University in October 2022. We excluded participants with hearing or speech disabilities. The questionnaire took approximately 20 min to complete. A total of 1,656 students responded to the invitation to participate in the study. Of these, 30 questionnaires were excluded because they have dozens of consecutive identical item responses on given scales; thus, the valid questionnaire rate was 98.19%. This study was approved by the Ethics Committee of Binzhou Medical University (NO 2021–281).

Measures

Anxiety

Anxiety was assessed using the Anxiety subscale of the Chinese version of Depression, Anxiety, Stress Scales-21(DASS-21) (33). This subscale has 7 items that measure the level of anxiety over the past week, and the answers were reported on a 4-point scoring system (0 = did not apply to me at all, 3 = applied to me very much). Anxiety was calculated by adding up the scores of the items, and the scores were multiplied by two (34, 35). With higher scores indicating greater levels of anxiety. In the present study, the Cronbach's α for this subscale was 0.80.

Boredom proneness

The validated Chinese version of the Short Boredom Proneness Scale was used to measure the proneness of boredom over the previous time (36). The scale comprises 8 items, which are answered on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). Higher total scores indicate a higher tendency to experience boredom. In this study, the Cronbach's α for this scale was 0.91.

Self-control

Self-control was evaluated using the Chinese version of the Self-Control Scale complied by Tangney et al. (37). This instrument contains 13 items. Participants answered each item on a 5-point Likert scale, from "not at all like me" (tagged with 1) to "very much like me" (tagged with 5), with higher scores indicating higher degrees of self-control. This measure had good internal consistency (α = 0.76).

Smartphone addiction

Smartphone addiction was measured using the Chinese version of the Smartphone Addiction Scale-Short Version (SAS-SV), which was developed by Kwon and colleagues (38, 39). The scale consists of 10 items that are scored on a 6-point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree, and the summed score ranges from 10 to 60. The higher scores reflect higher levels of smartphone addiction. The Cronbach's α for this scale was 0.91.

Data analysis

The distribution of the study variable was analysed using a P–P plot, which showed that study variables were normally distributed. Basic participant characteristics are presented as descriptive statistics. Pearson's correlation analysis was used to detect the associations among the studied variables. The common method variance (CMV) that may potentially exist in self-reported data was explored by the Harman's single-factor test. The severity of multi-collinearity was checked using the variance inflation factor (VIF) at a cut-off point of 5 and tolerance (TOL) with a threshold of 0.1.

The simple linear regression model was used to explore confounding factors. Multiple linear regression analyses *via* SPSS 20.0 and Model 6 of the PROCESS macro in SPSS were used to assess the multiple mediating effects of boredom proneness and self-control in the association between anxiety and smartphone addiction. In this study, 5,000 bootstrapped samples were drawn from the data, and bias-corrected 95% confidence intervals (CI) were calculated. There is significant effect if 95% CI does not include zero.

Results

Testing for common method bias and multi-collinearity

Harman's single-factor test extracted 7 factors with eigenvalues greater than 1. The first factor explained 29% of the total variances, which was below the recommended threshold of 50% (40, 41). Thus, we concluded that CMV was not a serious problem in this study. Multi-collinearity diagnostics showed the ranges of the VIF and TOL were 1.35 to 1.60 and 0.63 to 0.74, respectively, which were far from the threshold. We, therefore, concluded that there was no multi-collinearity problem in our study.

Participant characteristics

The study sample comprised 505 (31.06%) male and 1,121 (68.94%) female participants, and the mean age was 19.24 years (SD = 1.19 years). Among the 1,626 participants, 55.47% ($n = 902$) were rural students, and 38.93% ($n = 633$) were clinical medical students. Students whose monthly consumption was less than 1,500 RMB accounted for 48.95% ($n = 796$) of the sample. See Table 1 for details.

Correlation analyses and smartphone addiction levels

Table 2 provides the means, standard deviations, and correlations between all studied variables. As expected, anxiety ($r = 0.36$, $p < 0.01$) and boredom proneness ($r = 0.42$, $p < 0.01$) were positively correlated with smartphone addiction, whereas, self-control was negatively related to smartphone addiction ($r = -0.53$, $p < 0.01$). In addition, anxiety was positively associated with boredom proneness ($r = 0.44$, $p < 0.01$), and negatively correlated with self-control ($r = -0.46$, $p < 0.01$). Boredom proneness was negatively related to self-control ($r = -0.57$, $p < 0.01$). The scores obtained from the Smartphone

TABLE 1 Sociodemographic characteristics of the participants.

Variables		*n*	%
Age	$\bar{X} \pm S$	19.24 ± 1.19	
BMI	$\bar{X} \pm S$	22.68 ± 5.39	
Gender	Male	505	31.06
	Female	1,121	68.94
Grade	Freshman	692	42.56
	Sophomore and above	934	57.44
Place of residence	Rural	902	55.47
	Urban	724	44.53
Ethnicity	Han Chinese	1,564	96.19
	Minority nationality	62	3.81
College major	Medicine	633	38.93
	Other	993	61.07
Monthly expenditures of student	<1,500 RMB	796	48.95
	1,500 RMB or more	830	51.05

TABLE 2 The descriptive analysis and correlations among studied variables.

Variables	1	2	3	4
1. Anxiety	1			
2. Boredom proneness	0.44**	1		
3. Self-control	−0.46**	−0.57**	1	
4. Smartphone addiction	0.36**	0.42**	−0.53**	1
Mean	4.81	25.90	45.20	30.89
SD	6.73	10.06	7.21	10.57

**$p < 0.01$.

Addiction Scale ranged from 10 to 60, and the average score was 30.89 ± 10.57.

Multiple mediation analyses

The simple linear regression model was used to primarily explore which sociodemographic characteristics would affect the multiple mediator models for smartphone addiction. Results showed that the relationship between gender and boredom proneness; the relationships between place of residence, college major and self-control; and the relationships between age, gender, grade, place of residence, college major and smartphone addiction were significant ($p < 0.05$). Therefore, these significant sociodemographic variables were included in the later multiple regression models as confounding factors.

We conducted three models to test the mediators of boredom proneness and self-control in the relationship between anxiety and smartphone addiction (Table 3). In model 1, anxiety was significantly associated with boredom proneness ($B = 0.66$, $p < 0.001$). In model 2, results showed that anxiety ($B = -0.27$, $p < 0.001$) and boredom proneness ($B = -0.32$, $p < 0.001$) was significantly associated with self-control, respectively. In model 3, we found that anxiety ($B = 0.19$, $p < 0.001$), boredom proneness ($B = 0.16$, $p < 0.001$) and self-control ($B = -0.56$, $p < 0.001$) were significantly associated with smartphone addiction, respectively. We, therefore, considered that anxiety had not only a direct and positive impact on smartphone addiction but also an indirect effect on smartphone addiction through boredom proneness and self-control. Boredom proneness and self-control also sequentially mediated the relationship between anxiety and smartphone addiction (Figure 1).

In addition, we reconfirmed the total, direct and indirect effects by employing Model 6 of the PROCESS macro in SPSS to perform a bias-corrected percentile bootstrap method (Table 4). Results showed that the indirect effects of anxiety on smartphone addiction through boredom proneness (effect = 0.10, 95% CI = 0.06–0.15) and self-control (effect = 0.16, 95% CI = 0.13–0.20) were significant; boredom proneness and self-control also had a sequential mediating effect in the link between anxiety and smartphone addiction (effect = 0.12, 95% CI = 0.10–0.15), as zero was not contained in the 95% CI. The total effect in the link between anxiety and smartphone addiction was the sum of the direct and indirect effects, which was 0.56. Among them, the direct effect was 0.18, which accounted for 32.14%; the sole mediation effect of boredom proneness accounted for 17.86%; the sole mediation effect of self-control accounted for 28.57%, and the continuous path of boredom proneness and self-control accounted for 21.43% of the total effect.

Discussion

This study investigated the underlying mechanisms in the relationship between anxiety and smartphone addiction among college students. The results demonstrated that anxiety was significantly positively associated with smartphone addiction, and it could predict smartphone addiction through boredom proneness and self-control. Boredom proneness and self-control also sequentially mediated the relationship between anxiety and smartphone addiction. Our findings underscore the importance of anxiety as a potential factor in predicting smartphone addiction among college students, and provide a greater understanding of the role of boredom proneness and self-control in the underlying pathways between anxiety and smartphone addiction. These findings have certain important implications for teachers and educators to initiate interventions with the aim of reducing smartphone addiction among college students.

The scores obtained on the SAS-SV by college students in the present study ranged between 10 and 60, with an average of 30.89 ± 10.57 points, which was slightly lower than 33.81 to 38.72 points reported in previous studies with Chinese college students (8, 13). Data from another country also showed that scores of SAS-SV among college students had exceeded 30 points (42). Although, the differences in the results may be related to the cultural and social differences among the samples in the studies, the obviously higher scores recorded in those studies have indicated that smartphone addiction among college students is a public health concern. Therefore, it is imperative and urgent to investigate the influencing factors and

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TABLE 3 Multiple mediator models for anxiety on smartphone addiction.

Independent variables	Model1: (Boredom proneness)			Model2: (Self-control)			Model3: (Smartphone addiction)		
	B	SE	*t*	*B*	SE	*t*	*B*	SE	*t*
Constant	23.50	0.87	26.90***	52.70	0.78	67.59***	36.45	4.94	7.38***
Anxiety	0.66	0.03	19.84***	−0.27	0.05	−11.47***	0.19	0.08	5.03***
Boredom proneness				−0.32	0.02	−20.60***	0.16	0.03	6.08***
Self-control							−0.56	0.04	−14.71***
R^2	0.20			0.38			0.33		
F	199.42***			244.28***			98.64***		

***$p < 0.001$. Model 1 regarded gender as confounding factor; Model 2 regarded place of residence and college major as confounding factors; Model 3 regarded age, gender, grade, place of residence and college major as confounding factors.

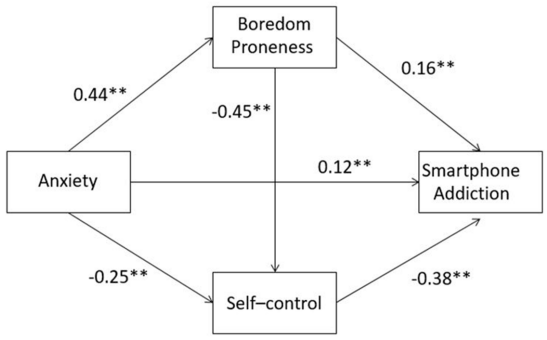

FIGURE 1
Multiple mediation effects model for anxiety predicting smartphone addiction (standard coefficents).

the underlying mechanisms of smartphone addiction among college students.

The results showed that anxiety had a significant positive association with smartphone addiction. This finding was in keeping with the conclusion drawn from previous studies that found that individuals with increased anxiety symptoms have an increased risk of smartphone addiction (6, 15, 43). A possible explanation is that people with anxiety tend to experience feeling of powerlessness and helplessness, and have a fear of being isolated from or even ostracised by the social communities (17, 44). This might lead them to repeatedly use a smartphone to be connected with others and alleviate this anxiety (6). Furthermore, excessive smartphone and Internet use could function as a natural, experiential avoidance coping mechanism for people to process negative emotions (19, 45). Hence, students experiencing higher levels of anxiety might opt to overuse their smartphones to alleviate their anxious mood and satisfy social needs. Our results provided further verification that anxiety is a crucial predictor of smartphone addiction. Thus, alleviating or reducing anxiety could decrease the risk of smartphone addiction.

Our study found that boredom proneness partially mediated the relationship between anxiety and smartphone addiction among college students, confirming Hypothesis 1. Regarding the first part of the path process of anxiety→boredom proneness, the result of this study was in line with the finding of another related study that boredom proneness arises when people experience anxiety (19). This can be explained by the constant feelings of helplessness, persistent worry, irrelevant thinking and social withdrawal, which is characteristic of anxiety, that may result in students being unable to find interest and significance in the engaged activity. The prolonged sense of idleness, tedium and emptiness will in turn elicit more boredom proneness in anxious people (20, 46). For the second part of the mediation process, namely, boredom proneness→smartphone addiction, the result of this study resembled the conclusion of previous empirical studies that found boredom proneness to be significantly correlated with smartphone addiction, and individuals who felt bored would spend more time using the smartphone to alleviate their boredom (23, 24). Individuals who score highly on boredom proneness experience impulse control problems, greater perceived task difficulty, and decreased attention dedicated to important tasks (21). Consequently, students experiencing boredom tend to engage in pleasurable smartphone usage to seek out more satisfying and stimulating activities to overcome boredom, which may lead to smartphone addiction (23, 24). The present study demonstrated that boredom proneness can be used to explain the correlation between anxiety and smartphone addiction from an emotional perspective. Therefore, smartphone addiction can be regarded as a compensatory response to relieve the proneness to boredom caused by anxiety.

Regarding Hypothesis 2, self-control partially mediated the relationship between anxiety and smartphone addiction. The first part of the mediation process, namely, anxiety→self-control, underlined anxiety as an important risk factor for self-control, which was consistent with previous observations that anxiety interferes with self-control (47). A possible explanation is that anxious individuals experience higher levels of apprehension and fear (10). To eliminate these negative emotional states, they may allocate their limited resources on emotion regulation or mental control. The depletion of self-control resources in some areas leads to a decline in the ability to exercise self-control (26). Our results supported the conclusion of a previous study that found individuals with low self-control were more likely to have addictive behaviours (27). A potential explanation is that individuals with high self-control are more likely to inhibit or resist temporary temptations, act in line with long-term goals and social standards, and think more about the consequences of their behaviours (48). Therefore, deficient self-control leads students to have difficulties controlling their problematic smartphone use and considering the negative consequences of addictive smartphone usage. This could lead

TABLE 4 Total, direct and indirect effects of anxiety on smartphone addiction.

Path	Effect	95%CI	Accounting for total effect,%
Anxiety→ smartphone addiction	0.18	(0.11,0.25)	32.14
Anxiety→ boredom proneness→ smartphone addiction	0.10	(0.06,0.15)	17.86
Anxiety→ boredom proneness→ self-control→ smartphone addiction	0.12	(0.10,0.15)	21.43
Anxiety→ self-control→ smartphone addiction	0.16	(0.13,0.20)	28.57
Total indirect effect	0.38	(0.32,0.45)	67.86
Total effect	0.56	—	—

students with lower self-control to have a higher likelihood of developing smartphone addiction (25, 29). Thus, anxious students with a lower degree of self-control would have a higher risk of developing smartphone addiction. Therefore, improving self-control in anxious college students may alleviate their problematic use of smartphones and help them manage their addiction.

The findings of our study indicated that anxiety affected boredom proneness and in turn boredom proneness affected smartphone addiction through the mediating role of self-control among college students, which supported Hypothesis 3. In other words, boredom proneness and self-control sequentially mediated the impact of anxiety on smartphone addiction. The results were consistent with evidence from a previous empirical study that boredom proneness was associated with poor self-control skills, which may lead to a greater likelihood of using the smartphone inappropriately or becoming addicted (24). A possible explanation is that boredom proneness accompanied by a neutral state of vapidity or disinterest creates the motivation to explore the surrounding environment beyond the task at hand to seek meaningful, interesting, or exciting activities, which consumes the individual's limited energy resources impairing self-control, and further boosting the risk of smartphone addiction (24, 29, 31). Therefore, the multiple mediation model provides a significant in-depth underlying explanatory mechanism that suggests boredom proneness and self-control are involved in the impact of anxiety on smartphone addiction.

Implications

Clarifying the mechanism of smartphone addiction is especially necessary in the context in which addictive smartphone use among adolescents and young adults has become a widespread public health issue. Our findings may bring out certain important implications for school educators to conduct measures alleviating the phenomenon of smartphone addiction in college students. First, these results provide a reference regarding the phenomenon of addictive smartphone use among college students and deepen the understanding of the mediating roles in clarifying the mechanism of smartphone addiction. Second, since anxiety and boredom proneness are positively associated with smartphone addiction, future interventions need to focus on alleviating students' negative emotions are necessary in future interventions. Third, self-control significantly decreases smartphone addiction, which suggests the great importance of improving self-control to reduce the occurrence of smartphone addiction among college students.

Limitations and further research

Our study verified the effect mechanisms in the link between anxiety and smartphone addiction, providing a reference for future research on smartphone addiction. Nevertheless, this study had several limitations. First, the cross-sectional design and the evidence provided by such a study can be considered associative and insufficient to draw causal inferences. In the future, a longitudinal study is required. Second, apart from boredom proneness and self-control, there are likely other variables that affect the relationship between anxiety and smartphone addiction. Future research should investigate other possible mediators to explain the pathway involved in the impact of anxiety on smartphone addiction. Finally, we surveyed college students mainly focusing on freshmen and sophomore from one university. Although a significant explanation was provided for the tendency of individuals with anxiety to have smartphone addictions, the selection of samples may limit the generalizability of our results. Future studies should broader settings to confirmed study findings.

Conclusion

This study provides evidence that anxiety could positively predict smartphone addiction in college students. Furthermore, boredom proneness and self-control mediate the link between anxiety and smartphone addiction in a parallel and sequential manner. To attenuate smartphone addiction among college students, it is critical to focus on student's negative emotion (anxiety, boredom proneness) and self-control ability. Therefore, schools should pay more attention to the issue of negative emotions among college students and develop early preventive and intervention measures to eliminate this phenomenon, such as, increase social support including the development of open access about mental health services to meet their psychological needs, design programs motivating students to participate in greater physical activity to attenuate anxiety and recreational social practice activities for their leisure time to relieve boredom proneness. Furthermore, more attention should be given to college students with low levels of self-control in smartphone addiction interventions. Effective training to strengthen self-control can improve self-monitoring and self-awareness, which can aid in resisting negative behaviours. Regular practice and group cognitive-behavioural therapy may be effective ways to strengthen college students' self-control ability.

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 Ethics Committee of Binzhou Medical University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

LZ had the original idea for the study and carried out the design and drafted the manuscript. QX and CF provided valuable insight regarding the methodological approach and organization of the manuscript. LZ and BW carried out the statistical analysis and provided summaries of previous research studies and revised the manuscript. All authors contributed to the article and approved the submitted version.

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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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Does the need for uniqueness lead to non-suicidal self-injury? The mediation of depression and the moderation of gender

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Objective: Based on the integrated theoretical model of the development and maintenance of non-suicidal self-injury (NSSI) and gender role theory, this study investigated the longitudinal impact of the need for uniqueness on NSSI among adolescents, and the mediating role of depression and the moderating role of gender.

Participants: A total of 1,166 middle school students ($Mean_{age}$ = 13.04, SD_{age} = 0.78, range = 11–16) from a city in central China was recruited to complete the Need for Uniqueness Scale, Depression Scale, and Adolescent Self-Injury Questionnaire at two waves. The participants included 475 boys and 457 girls.

Methods: Convenience sampling was used, and a longitudinal study (2 time points with a 6-month interval) was conducted to test our hypotheses. SPSS 25.0 was used to evaluate reliability, and to calculate descriptive statistics and Pearson correlation. PROCESS version 3 was used to test longitudinal relationships among the need for uniqueness, depression and NSSI, and construct a moderated mediation model.

Results: Results revealed that T1 need for uniqueness in adolescents was significantly positively associated with T2 NSSI and T2 depression, and T2 depression was significantly positively associated with T2 NSSI. After controlling for gender, T1 need for uniqueness positively predicted T2 NSSI. Furthermore, the mediation analysis demonstrated that the pathway linking T1 need for uniqueness to T2 NSSI through T2 depression was statistically significant. Moreover, gender moderated the indirect effect from T2 depression to T2 NSSI in the association between T1 need for uniqueness and T2 NSSI. Compared to boys in the same situation, girls who are susceptible to depression were more likely to commit NSSI.

Conclusion: This study demonstrated that the need for uniqueness in adolescents longitudinally predicts NSSI through the mediating role of depression and gender moderates the indirect effect from depression to NSSI. The current study not only suggests that the need for uniqueness is a risk factor for NSSI among adolescents, but also provides an empirical basis for the prevention and intervention of NSSI.

KEYWORDS

demoralization, depression, gender role, interpersonal relations, need for uniqueness, non-suicidal self-injury, suicide, suicide attempt

1. Introduction

Self-injury has become a significant public health problem among adolescents worldwide (1, 2). Non-suicidal self-injury (NSSI) refers to individuals intentionally harming themselves without the intention of suicide, including behaviors such as cutting themselves with a knife, burning themselves with cigarettes, intentionally hitting themselves, and other deliberate, direct damage or altering of bodily tissue behaviors (3, 4). The prevalence rate of NSSI among adolescents can be up to 57% (5). Specifically, a meta-analysis reported an aggregate lifetime prevalence of NSSI in Chinese adolescents at 22.1%, with a 12-month prevalence of 19.5% (6), and the prevalence of NSSI in Iranian young adults and adolescents was 4.3 to 40.5% (7). Although an individual suffering from NSSI has no initial intent to commit suicide, previous researchers have found that early NSSI is an important predictor of future suicidal ideation and behavior (8–11). For instance, a meta-analysis of relevant studies conducted in both English and Chinese populations revealed a co-occurrence rate of NSSI and suicide attempt at 26% (12). Furthermore, NSSI is positively associated with many mental disorders, such as borderline personality disorder and depression (13). Given the potential harm of NSSI and adolescents being a high-risk group of NSSI (14, 15), it is noteworthy to explore the factors and underlying mechanisms of NSSI.

Previous studies have showed that the main factors leading to NSSI involve genetic, physical (e.g., biological pain, endocrine system and weakened immune systems) and social facets (e.g., poor socioeconomic status, toxic interpersonal exposures and migration), as well as psychiatric disorders (e.g., Borderline Personality Disorder and sleep disorders) (3, 16–20). Among these factors, the effect of basic psychological needs (autonomy, competence, and relatedness) on NSSI has received some attention from a few researchers (16). However, the influence of the need for uniqueness on NSSI has remained unexplored.

Snyder and Fromkin (21) defined the need for uniqueness as the individually psychological need in pursuit of uniqueness and distinctness from other people. In addition, the motivated identity construction theory maintains that the need for uniqueness is theorized as an identity motive, which plays a leading role in the process of identity construction (22). Adolescence is a crucial period of identity construction and adolescents are prone to identity crisis (23). Therefore, adolescents may seek to fulfill the need for uniqueness as a way to deal with identity crisis. However, the need for uniqueness may lead to social punishment particularly within collectivist culture where conformity and group harmony are highly regarded (24).

Previous studies have indicated that the need for uniqueness is positively associated with negative emotions, such as anxiety and depression (25). As negative emotions are often a significant trigger of NSSI in adolescents (26), we assume that the need for uniqueness may be positively associated with NSSI in adolescents. Although China is considered a typical collectivist society, people's need for uniqueness has dramatically risen in recent years, likely influenced by Western individualistic culture (27). In sum, investigating the relationship between the need for uniqueness and NSSI among adolescents holds both theoretical and practical implications.

1.1. Need for uniqueness and NSSI

The need for uniqueness is a universal psychological need emphasizing individual desire for being different from others. Driven by this psychological need, people will display their uniqueness through various behaviors. For example, when choosing names and nicknames, individuals with a higher need for uniqueness tend to choose more uncommon names than do their counterparts (27, 28). With respect to shopping, individuals high in need for uniqueness prefer unconventional product appearances and niche brands and often avoid the popular choices (29).

Although displaying uniqueness can satisfy Chinese adolescents' psychological needs, it may trigger social ostracism or rejection (30, 31). The pursuit of uniqueness is widely encouraged within individualistic culture, whereas, unwelcome within collectivistic culture (32). Individuals who display uniqueness in China, generally considered a collectivistic country, may be seen as social misfits who challenge collective consistency and violate social norms (33). Therefore, individuals who manifest uniqueness may face social punishment such as social ostracism and rejection from other members within the collective culture (34).

According to the social signaling hypothesis, NSSI can be an effective strategy to communicate social signals in certain situations despite the physical pain it brings (3, 35). When adolescents encounter bullying or difficult situations, NSSI may serve as a powerful way to convey their pain, despair or anger to other people (36). For instance, social ostracism or rejection can be particularly distressing for adolescents because they tend to prioritize peer relationships (37, 38). As adolescents often lack the social skills to manage such situations through normal communication, they may deliver how deeply they have been hurt *via* NSSI to the people who, they suppose, may care about them (25, 39). Previous studies have shown that adolescents who experience peer ostracism, rejection, or bullying have a higher risk of self-harm (15, 40). Thus, adolescents who feel isolated or rejected due to manifestation of uniqueness are likely to resort to NSSI to express their difficult experiences (41).

Hereby, we propose Hypothesis,

> *H1*: The need for uniqueness is positively associated with NSSI.

1.2. The mediating role of depression

To intervene in NSSI more effectively, it is also necessary to study the underlying mechanism on the path that the need for uniqueness leads to NSSI. According to the integrated theoretical model of the development and maintenance of NSSI, NSSI can be influenced by both distal risk factors (e.g., childhood abuse, familial hostility) and intrapersonal vulnerability factors (e.g., high aversive emotions), and that distal risk factors function through intrapersonal vulnerability factors (42). In this model, the need for uniqueness is considered as a distal risk factor, while depression is considered as an intrapersonal vulnerability factor (42). The model also indicates that the distal risk factor of the need for uniqueness may influence NSSI through the intrapersonal vulnerability factor of depression (43–46).

On the one hand, the need for uniqueness may be positively associated with depression. Depression is a typical negative emotion characterized by low mood, loss of interest, and a sense of worthlessness (47, 48). Beck's cognitive theory of depression proposes that negative cognition about the world and the self-play a critical role in the development of depression (49). The need for uniqueness may lead to negative cognition about the world in which they live. China

is a typical collectivistic culture where the pursuit of uniqueness is not encouraged (25, 32). This social environment can be challenging for adolescents high in need for uniqueness, who may feel that their needs cannot be met and their true selves cannot be expressed (50) leading to the dissatisfaction with their circumstances and a negative cognition about the world, for example, "I live in a very bad world."

Furthermore, the need for uniqueness may lead to a negative cognition about the self. According to the looking-glass self-theory, people often form their self-perception by referring to social feedback (51). Within collectivist culture, unique behaviors often go against the conventional consensus and disrupt collective consistency, leading to individual dissatisfaction about the group and rejection from other group members (34). Prolonged rejection by group members may cause Chinese adolescents to develop negative self-images (50, 52). For instance, those high in need for uniqueness outcasts may feel frustrated in this situation and even may view themselves as undesirable figures in social circumstances (53).

On the other hand, depression may be positively associated with NSSI among adolescents. The experience avoidance model posits that when individuals experience negative emotions which are difficult to endure and regulate, they may resort to NSSI as an extreme means of escape (26, 54). Depression is a painfully negative emotion, and adolescents usually lack adequate emotional regulation skills to cope with it (55, 56). When depression strikes, adolescents may feel as if they are sinking into a swamp and instinctively seek to escape (57). Nevertheless, NSSI is often accompanied by intensely physical pain, which acts as a ways of attention shifting to help adolescents escape from negative emotions. The acutely physical pain can readily capture an individual's attention and shift their focus away from internal emotional experiences to external physical experiences (26, 54, 58). Suppressing the psychological pain of depression by bearing the physical pain of NSSI, adolescents may consider NSSI to be an effective means to avoid negative emotions (59, 60). Empirical studies also revealed a positive correlation between adolescent depression and NSSI (40, 61).

Thus, we propose Hypothesis,

> *H2*: Depression mediates the association between the need for uniqueness and NSSI; the need for uniqueness is positively associated with depression, which is positively associated with NSSI.

1.3. The moderating role of gender

Drawing from the experiential avoidance model, although negative emotions such as depression and anxiety can trigger NSSI, this process is influenced by the individual's ability to regulate negative emotions (26). When individuals are incapable of regulating their negative emotions which are caused by stressful events, NSSI may become the priority option to relieve the intensely painful feelings (62–64). Previous studies have found that the ability and styles of regulating negative emotions differ significantly between genders (62–66). Therefore, gender may moderate the relationship between negative emotions (e.g., depression) and NSSI. More precisely, female adolescents experiencing depression are at a greater likelihood of engaging in NSSI than their male counterparts experiencing depression.

According to gender role theory, men and women are given different social expectations during socialization and their social behaviors are guided by different social norms, resulting in different ways of thinking, feeling, and behaving (67, 68). Men are commonly expected to take on the roles which emphasize responsibility, patience, and emotional stability (63). Those expectations require men to exercise strong emotional control and avoid excessive emotional involvement (65, 69). In contrast, women are often assigned gender roles where society tends to tolerate their emotional expression, even allowing them to behave petulantly (67, 68). These distinct gender role expectations lead to differences in the development of emotional regulation skills and styles. Men usually have stronger emotional regulation efficacy and more dispassionate emotional regulation styles than do women (62–66). Empirical studies have shown that females are more likely to ruminate when experiencing sadness or depression, compared to males (65, 70, 71). For men with depressive symptoms, their stronger sense of emotional regulation efficacy and more dispassionate emotional regulation styles (e.g., cognitive reappraisal) (62, 63, 65, 66), may protect them from turning to NSSI for emotional regulation. However, women with depressive symptoms may have weaker emotional regulation efficacy and more distressing emotional regulation styles, for example, rumination (65, 70, 71). Therefore, they may be more likely to regulate their emotions by NSSI than men.

Accordingly, we propose Hypothesis H3: Gender moderates the indirect effect of depression on NSSI in the association between the need for uniqueness and NSSI (Figure 1). Compared to girls, depression has a greater impact on among boys.

2. Methods

2.1. Participants and design

The present study received approval from the Ethics Committee for Scientific Research at Qingdao University, indicating that the study design and methods adhere to established ethical standards in scientific research. The sampling method utilized in this study was convenience sampling. Graduate students specializing in psychology and trained in research methodology carried out this investigation. A total of 1,166 adolescents were recruited from three middle schools located in a city in central China. Prior to formal testing, consent was obtained from participants and their parents or guardians for the use of their responses in our research. We ensured that they fully understood each step of the survey process through appropriate ways such as providing detailed instructions and sufficient time for questions, assisting participants with difficult questions, and emphasizing that participation was optional and anonymous.

The study involved two assessments with a 6-month interval (Time 1 and Time 2). T1 collecting demographic variables as controlling variables and the need for uniqueness as an independent

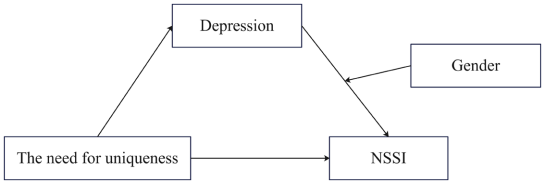

FIGURE 1
The proposed moderated mediation model.

variable. T2 measured depression as a mediating variable and NSSI as a dependent variable.

The survey includes 1,166 adolescent participants at Time 1. Among them, 541 were females, and 601 were males. Six months later in Time 2, the students' participation number decreased from 1,166 to 970. Attrition (196 students) resulted from participants' absenteeism or refusal to participate in the study. Additionally, 38 students' answers were excluded due to incompletion. Consequently, the final sample for analysis comprised 932 middle school students, which comprised 457 (49.03%) females and 475 (50.97%) males. Their ages range from 11 to 16 ($M = 13.04$, $SD = 0.78$).

2.2. Measures

2.2.1. Need for uniqueness

Need for Uniqueness Scale developed by Lynn and Harris (69) was used in the study. The scale was revised into a Chinese version by Cai and Zou (27) with good reliability and validity. It consists of 4 items, such as "It's very important for me to be different." A total of 4 items were scored on a five-point Likert scale with 1 (strongly disagree) to 5 (strongly agree). Higher scores indicated a greater need for uniqueness among the adolescents. The Cronbach's alpha coefficient for the scale was calculated to be 0.86.

2.2.2. Depression

In this study, we utilized the Depression-Anxiety-Stress Scale-21 (DASS-21) developed by (72), which has a revised Chinese version (45). To measure depression, we used the depression subscale, which includes 7 items, such as "I find it difficult to take the initiative to start working," and responses were scored on a five-point Likert scale ranging from "0" for "not at all" to "3" for "very much." Higher scores indicated a higher level of depression. The Cronbach's alpha coefficient for the scale used in this study was calculated to be 0.86.

2.2.3. Non-suicidal self-injury

The Adolescent Self-Injury Questionnaire was revised into a Chinese version by Feng (43) with good reliability and validity. The questionnaire consists of 18 items, such as "Using a cigarette, lighter, or other instruments, deliberately burn or scald your skin." The frequency of NSSI was examined on four levels: 0 times, 1 time, 2–4 times, and more than 5 times (including 5 times). The mean scores across the 18 items were used to assess NSSI. Higher scores indicate more instances of NSSI for the adolescents. Cronbach's alpha for the scale in this study was 0.90.

2.3. Data analysis

In this study, all data analyses were performed using SPSS 25.0. First, descriptive statistics and Pearson correlation analysis were conducted to explore the data. Second, PROCESS version 3 was used to test longitudinal relationships among the need for uniqueness, depression and NSSI, and construct a moderated mediation model (73). After standardizing all continuous variables, gender was converted into a dummy variable, with boys coded as 0 and girls coded as 1. For the purpose of approximating the confidence interval (CI) of the indirect impact, 5,000 boot-strapped samples were created. Statistical significance was demonstrated by a 95% bias-corrected accelerated CI that did not contain zero.

3. Results

3.1. Preliminary analyses

Means, standard deviations, and Pearson's correlations of all variables were calculated and are shown in Table 1. As the results indicated, T1 need for uniqueness was positively associated with T2 depression ($r = 0.18$, $p < 0.01$) and T2 NSSI ($r = 0.11$, $p < 0.01$). T2 depression was positively associated with T2 NSSI ($r = 0.51$, $p < 0.01$).

3.2. Mediation analyses

After all variables were standardized and gender was converted into a dummy variable, with boys coded as 0 and girls coded as 1, Model 4 of PROCESS (73) was conducted to examine the longitudinal impact of need for uniqueness on NSSI among adolescents as well as the possible mediating effect of depression. As indicated in Table 2, after controlling for gender, T1 need for uniqueness positively predicted T2 NSSI ($\beta = 0.10$, $p < 0.01$, Eq.1); T1 need for uniqueness positively predicted T2 depression ($\beta = 0.18$, $p < 0.001$, Eq. 2), the direct association between T1 need for uniqueness and T2 NSSI was not significant ($\beta = 0.01$, $p > 0.05$), and T2 depression positively predicted T2 NSSI ($\beta = 0.50$, $p < 0.001$, Eq.3). The bias-corrected bootstrapping mediation test illustrated that the process by which T1 need for uniqueness predicted T2 NSSI through T2 depression was significant, *indirect effect* = 0.09, *Boot SE* = 0.02, 95% *CI* = [0.06,0.13]. The results of the mediation analysis support H1 and H2.

3.3. Moderation analyses

Model 14 of PROCESS (73) was conducted to investigate whether gender moderated the association between T2depression and T2 NSSI. The results of the moderation analyses were showed in Table 3. The results of the moderation analysis support H3. The regression model suggested the T1 need for uniqueness was not a significant predictor of T2 NSSI ($\beta = 0.01$, $t = 0.47$, $p > 0.05$), while T2 depression positively predicted T2 NSSI ($\beta = 0.42$, $t = 10.38$, $p < 0.001$). Moreover, the interaction between gender and T2 depression was associated with T2 NSSI ($\beta = 0.17$, $t = 3.01$, $p < 0.01$), with a 95% confidence interval of [0.06, 0.28] and did not contain 0. The results indicated that gender played a moderating role in the relationship between T2 depression and T2 NSSI, and hypothesis

TABLE 1 Means, standard deviations, and correlations for the main variables ($N = 932$).

Variables	*M*	*SD*	1	2	3
1. T1 Need for uniqueness	2.05	0.99	–		
2. T2 Depression	0.59	0.71	0.18**	–	
3. T2 NSSI	1.22	0.38	0.11**	0.51**	–

$N = 932$. **$p < 0.01$. NSSI, non-suicidal self-injury.

TABLE 2 The mediation model.

Predictors	Equation 1 (Criterion = T2 NSSI)			Equation 2 (Criterion = T2 Depression)			Equation 3 (Criterion = T2 NSSI)		
	β	*SE*	*t*	*β*	*SE*	*t*	*β*	*SE*	*t*
Gender	0.10	0.07	1.59	0.10	0.06	1.55	0.05	0.06	0.94
T1 Need for uniqueness	0.10	0.03	3.20**	0.18	0.03	5.61***	0.01	0.03	0.46
T2 Depression							0.50	0.03	17.47***
R^2	0.01			0.04			0.26		
F	6.43**			17.02***			107.43***		

**$p < 0.01$, ***$p < 0.001$. NSSI, non-suicidal self-injury.

TABLE 3 The moderation model.

Predictors	Equation (Criterion = T2 NSSI)		
	β	*SE*	*t*
Gender	0.05	0.06	0.95
T1 Need for uniqueness	0.01	0.03	0.47
T2 Depression	0.42	0.04	10.38***
T2 Depression × Gender	0.17	0.06	3.01**
R^2	0.27		
F	83.54***		

**$p < 0.01$, ***$p < 0.001$. NSSI, non-suicidal self-injury.

H3 was tested. As illustrated in Figure 2, simple slope tests indicated that compared with boys ($\beta = 0.42$, $t = 10.38$, $p < 0.05$), T2 depression has a greater impact on T2 NSSI in girls ($\beta = 0.59$, $t = 14.64$, $p < 0.01$).

4. Discussion

Drawing on the integrated theoretical model of the development and maintenance of NSSI, we investigated the longitudinal impact of T1 need for uniqueness on T2 NSSI among adolescents in China. Additionally, we examined the mediation of depression and the moderation of gender. Results revealed that T1 need for uniqueness in adolescents was significantly positively associated with T2 NSSI and T2 depression, and T2 depression was significantly positively associated with T2 NSSI. After controlling for gender, T1 need for uniqueness positively predicted T2 NSSI. Furthermore, the mediation analysis demonstrated that the pathway linking T1 need for uniqueness to T2 NSSI through T2 depression was statistically significant. Moreover, gender moderated the indirect effect from T2 depression to T2 NSSI in the association between T1 need for uniqueness and T2 NSSI. Compared to boys in the same situation, girls who are susceptible to depression were more likely to commit NSSI.

4.1. Relationship between the need for uniqueness and NSSI among adolescents

This study indicated that the T1 need for uniqueness was positively associated with T2 NSSI among adolescents, which supported hypothesis H1. The results surprisingly revealed an adverse effect of the need for uniqueness on adolescents' mental and behavioral problems (53, 74), and broadened the research area of the need for uniqueness. Previous research suggested that NSSI was associated with basic psychological need for competence, autonomy, and relatedness (16, 75), but few researchers focused on the need for uniqueness. According to the optimal distinctiveness theory, the need for uniqueness is closely related to individual adaptation (30, 76).

Since China has undergone significant cultural and psychological changes as a result of social and economic transformation during the past century, the contemporary Chinese society has witnessed the rise of individualistic values and the collapse of traditional values (77, 78). Although the need for uniqueness among adolescents is increasing in China (27), previous research studies focused mainly on the field of marketing (29, 79) and few studies have examined the need for uniqueness from the perspective of adolescent development. This study found that adolescents high in need for uniqueness were more likely to engage in NSSI, indicating that the need for uniqueness is a risk factor for adolescents' NSSI.

Therefore, we suggest that the family, educational system and the public be aware of the potential danger of adolescents' pursuit of uniqueness. It might be considered universally effective for adolescents across the world too, satisfy the need for uniqueness by wearing unusual clothes or cutting maverick hair (80). Within collectivist culture, however, doing so may violate the values and norms of collectivism and possibly leads to social ostracism and peer bullying (34). Based on the social signaling hypothesis, adolescents who experience bullying and social exclusion may vent their pain by harming themselves, considering that they usually lack mature social skills to handle these issues (3, 35). Recent researches have also revealed that adolescents' craving for uniqueness causes negative outcomes, such as anxiety and addictive behaviors (81).

4.2. The mediating role of depression

The present study demonstrated that the T1 need for uniqueness among adolescents was positively associated with T2 NSSI through the mediating role of T2 depression, which was consistent with hypothesis H2. According to the person-environment fit theory, how well adolescents adapt to their environment depends on how well their individual characteristics match that environment (82). Chinese adolescents with higher need for uniqueness often desire to be different and stand out from the crowd. Nonetheless, their need for uniqueness is incompatible with the demands of the collectivist

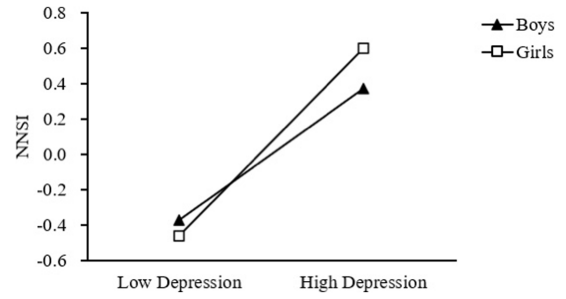

FIGURE 2
Gender moderated the relationship between depression and NSSI.

environment, which may hinder personal growth and lead to maladjustments, for instance, depression and NSSI (81).

The results of this study supported the integrated theoretical model of the development and maintenance of NSSI, which maintains that the likelihood of NSSI can result from distal variables through intrapersonal vulnerabilities (3, 35). The study revealed that the need for uniqueness, as a distal risk factor can cause NSSI through intrapersonal vulnerability factor (depression). This result is consistent with previous studies, indicating that individual characteristics, such as self-criticism, alexithymia, distress tolerance, and behavioral inhibition system/behavioral approach systems, influence NSSI through the mediating role of negative emotions, such as depression and psychache (46, 83, 84).

The current study not only elucidates a mechanism underlying the association between the need for uniqueness and NSSI, but it also explored and tested another detrimental impact of fulfilling the need for uniqueness, i.e., depression. Furthermore, this study expands the application scope of the integrated theoretical model of the development and maintenance of NSSI.

4.3. The moderating role of gender

This present study found that gender moderated the association between T2 depression and T2 NSSI. Specifically, depression had a greater impact on NSSI in girls than in boys, which was consistent with hypothesis H3. Social norms demands more responsibility, patience and emotional stability from men than from women (85). This difference in gender roles results in different regulatory emotional self-efficacies and emotion regulation strategies between men and women when dealing with problems. Specifically, compared to women, men may develop a higher level of regulatory emotional self-efficacy (66) and more composed ways of regulating emotions (62, 63, 65). Previous research has shown that males tend to utilizing cognitive reappraisal strategies when in depressive mood, whereas females are more prone to rumination (71, 86). Based on the experiential avoidance model of NNSI, when girls are incapable of regulating their emotions, they are more likely to escape negative emotions through NSSI that accompanies intense physical pain (26, 54).

An alternative explanation for gender difference is stress response. Adolescents with depressive symptoms may experience low spirits, retarded thinking and decreased motivation (57). Their worsened mental states may suspend the functioning of their study and daily life, which results in a situation where they are under much stress (87, 88). Compared with men, women are more likely to report physical symptoms associated with stress (89). Similarly, it is reasonable to assume that girls who suffer from depressive mood have more physical symptoms than do their boys counterparts. Given that physical symptoms are closely associated with NSSI (20), girls who suffer from depressive mood are more likely than boys in the same situation to conduct NSSI.

The present result was consistent with earlier research, which has found that depression has a greater effect on suicidal thoughts among adolescent girls than among adolescent boys (44, 90). These findings suggest that more attention should be paid to adolescent girls with depression, because they are more vulnerable to NSSI than adolescent boys with depression.

4.4. Theoretical and practical implications

An important theoretical implication of our study is that this study is the first to examine the need for uniqueness on NSSI on an adolescent sample. we have found that the need for uniqueness increases NSSI, indicating that a positive individual trait from Western culture may lead to NSSI. This finding deepened our understanding of the factors that contribute to NSSI. Previous research has focused on the effect of explicitly negative characteristics (e.g., self-criticism, low self-esteem, and experiential avoidance) on NSSI (3, 20). Neutral factors or even positive factors in Western culture are relatively neglected.

Our current study centered on one positive individuals characteristic, distinctiveness, which not only is widely acclaimed in western society but epitomizes western values and liberal spirit (24). Uniqueness is a social value widely recognized in mainstream Western culture (30, 32, 91). It is also considered to be a positive individual characteristic and is essential in constructing one's self-identity and boosting self-esteem (30, 32). Empirical evidence has shown that a sense of distinctiveness is positively associated with optimism, hope, resilience, and positive self-evaluation, and it helps to enhance the individual psychological state (92, 93). Despite its widely accepted advantages, our results disclosed that the need for uniqueness may increase the risk of NSSI.

Another theoretical implication of our study is that this study enriches the theory of person-environment fit (82). According to this theory, individual adaptiveness depends on how well individual characteristics accords with the environment (82, 94). For example, individuals experience higher self-esteem when their personality matches the personality of the city they reside in than a mismatch (94). Similarly, better job performance is observed when individuals correspond to organizations (95). In terms of the current study, individuals adapt to the environment more easily when their need for uniqueness aligns with the cultural environment than when it does not fit the environment. Researchers have also found that while the need for uniqueness increases life satisfaction among American participants, it decreases life satisfaction among Japanese participants (76). Similar in the current study, the need for uniqueness, which is generally known to have positive effects in Western culture, can inflict harm on Chinese adolescents. This finding provides new evidence for the theory of person-environment fit.

Practical implications could also be drawn from the results of this study. Firstly, it is often clinically complex to distinguish between the presence or absence of suicidal intent, direct intervention to lessen suicidal ideation is challenging. However, compared to suicidal ideation, NSSI leaves physical traces on the body, such as cuts and cigarette burns, which implies that NSSI is easier to be discerned than is suicidal ideation (12). Previous studies have demonstrated that NSSI can significantly predict suicidal ideation (96–98). Therefore, to improve the precision of discerning suicidal intent, clinical practitioners can pay specific attention to NSSI in adolescents.

Secondly, as the need for uniqueness in China has been increasing, there is a danger that some adolescents pursue uniqueness through demonstrations of NSSI. Therefore, it is essential for schools and teachers to be aware of the negative impact of the need for uniqueness on NSSI among adolescents. If guiding adolescents to fulfill their need for uniqueness in an healthy manner, the potential negative effects on their mental health might be lessened.

Thirdly, given that practitioners usually utilize emotion regulation therapy to prevent adolescents from engaging in NSSI (99), this finding suggests that such therapy could also be used to assist adolescents who have already conducted NSSI. The government and schools are encouraged to organize psychological consulting or group therapy sessions to facilitate adolescents' mental health. For example, the negative effects of depression can be alleviated by developing positive emotion regulation strategies and good coping styles in adolescents through diverse approaches, such as group counseling, individual counseling, and public programs, thus reducing the risk of NSSI. Additionally, concerning that eliminating depression or depressive symptoms in a short-term is impractical, therapies such as Acceptance and Commitment Therapy (ACT) can be used to enhance the acceptance of depressive mental state (100, 101), which may further reduce the impact of depression on NSSI.

Finally, gender roles are crucial in dealing with negative emotions, and traditional female roles are not conducive to regulating negative emotions (63). Therefore, the government and schools can encourage parents to refresh their views of gender roles. Especially parents of adolescent girls can provide unbiased advice during gender socialization and guide them to manage negative emotions. Moreover, compared to boys, girls suffer from depression are more likely to conduct NSSI. The government and schools need to provide mental health courses and training related to emotional regulation for girls to improve their emotional regulation strategies and coping skills when experiencing negative emotions such as depression, thereby reducing NSSI.

4.5. Limitations

The first limitation was that this study focused on the relationship between the need for uniqueness and NSSI among Chinese adolescents, therefore the results cannot be simply generalized to other countries. According to the person environment fit theory, whether an individual trait is adaptive depends on the degree to which it matches the environment (102, 103). Therefore, the effect of the need for uniqueness on NSSI may vary across different social environments. Previous studies have found that although the need for uniqueness decreases satisfaction with life among Japanese people, it increases satisfaction with life among Americans (76). Therefore, the effect of the need for uniqueness on NSSI in individualistic culture may be potentially different from the present study, which is worth exploring in future cross-cultural studies.

The second limitation was that we only obtained homologous data, which could have led to shared variance among the variables and inflated the significance of the connections that were expected. Future study can recruit participants from various sources, such as parents and peers, to report on the same variables.

The third limitation was that NSSI and depression were not measured at baseline. Previous studies have found that NSSI was affected by both NSSI history and depression (40, 61, 104). However, due to the methodological limitations, we only measured depression and NSSI at Time 2. Future study on the relationship between depression and NSSI should measure NSSI and depression at baseline.

The final limitation is that only one mediator, depression, was considered in the current study. Future studies can test more mediators to further understand the mechanisms underlying the association between the need for uniqueness and NSSI. According to previous literature, we presume that demoralization is a possible mediator. Demoralization features hopelessness or disheartenment, loss of meaning in life, helplessness, sense of failure, and dysphoria (105, 106). Researchers believe that individuals may develop symptoms of demoralization when they cannot meet self and others' expectations (105, 106). Individuals high in need for uniqueness may find it difficult to live up to the expectations and thus succumb to demoralization. Collectivistic culture underlines consistency and similarity among group members, suggesting that adolescents may be expected by their parents, teachers and peers to behave similar to the way other people do and avoid standing out (33, 34). Therefore, adolescents high in need for uniqueness may be tormented by not meeting others' social expectations. In addition, displaying uniqueness may not only be disapproved, but even socially punished (24, 31). Under the circumstances, adolescents high in need for uniqueness are not allowed to be the authentic, unique self, i.e., fail to meet their own expectations. Furthermore, we assume that demoralization leads to NSSI. Individuals who suffer from demoralization may be desperate for escapism (106, 107), actions whose goal is to distract the psychological pain by enduring physical pain. In this situation, NSSI as a form of distraction would appeal to those individuals.

5. Conclusion

In conclusion, this study enhanced our comprehension of the risk factors that contribute to NSSI among Chinese adolescents, as well as the mechanism that how the need for uniqueness longitudinally leads to NSSI among adolescents in China. Specifically, the results indicate that depression acts as a mediator on the association between the need for uniqueness and NSSI, and that the association between depression and NSSI is moderated by gender. Compared to boys in the same situation, girls who are susceptible to depression were more likely to commit NSSI. The moderated mediation model provides valuable insights into the theoretical exploration of the need for uniqueness and NSSI, and offer potential avenues for relevant intervention.

Data availability statement

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

Author contributions

XZ, WC, and JF: conceptualization and methodology. XZ, WC, JF, and DH: writing – original draft. All authors contributed to the article and approved the submitted version.

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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

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The association between problematic internet use and social anxiety within adolescents and young adults: a systematic review and meta-analysis

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Objective: Although numerous studies have investigated the association between problematic internet use (PIU) and social anxiety, the findings have no yet reached consistent. The present meta-analysis aims to examine the association between PIU and social anxiety within adolescents and young adults (age range: 14–24years old).

Method: The meta-analysis systematically retrieved the studies prior to September 7, 2023 from Web of Science, PubMed, PsycINFO, Scopus, CNKI, and CQVIP. The meta-analysis based on random-effects model to conduct the research. Stata Version 17.0 and JASP 16.3.0 was used to analysis.

Results: The meta-analysis ultimately included 37 studies (37 effect sizes in total), involving a total of 36,013 subjects. Our findings indicated that the overall correlation between PIU and social anxiety was significant positive [$r = 0.333$, 95% CI (0.292, 0.373), $p < 0.001$]. Their association was significantly moderated by publication year, measurement tools for PIU and social anxiety but not significantly by culture context, developmental level and gender.

Conclusion: This meta-analysis suggests that social anxiety is a predictor of the development of PIU in adolescents and young adults. Furthermore, the study also finds the possibility that contemporary adolescents and youth may exhibit a more "global" behavior pattern, potentially emphasizing fewer differences between cultures, generations and genders.

KEYWORDS

internet addiction disorder, social anxiety, adolescent, young adult, systematic review, meta-analysis

1. Introduction

In light of the progressive development of information technology, an unprecedented increase in internet usage and dependency is observed. Concurrently, there is a significant upswing in the incidence of psychological issues associated with excessive online behavior, known as problematic internet use (PIU) (1). PIU is estimated to affect a noticeable portion of the general population, with a higher prevalence among adolescents and young adults. With studies suggesting that up to 9% of adolescents and young adults are at risk of developing PIU

symptoms (2). PIU can lead to the emergence of numerous psychological issues, such as social anxiety. Both these psychological problems and PIU can significantly impact academic performance, social relationships, and overall quality of life for affected adolescents and young adults (3).

Social anxiety in adolescents and young adults can lead to poor academic performance due to avoidance of classroom activities, hinder social interactions (4), elevate the risk of psychological issues like depression, and affect overall psychological well-being (5). Numerous factors can contribute to social anxiety in adolescents and young adults, including genetic predispositions (6), early traumatic events (7), among others. Notably, studies demonstrated that PIU uniquely predicts social anxiety among younger populations, as evidenced by out-of-sample LASSO model cross-validation (8). In addition, research has also substantiated a high comorbidity relationship between PIU and social anxiety within the adolescent and young adult populations (9). This correlation does not extend to adult and older age group. PIU can reduce social skills and intensify feelings of isolation, potentially exacerbating social anxiety symptoms (10).

Several theoretical models have shown that PIU can lead to social anxiety. The cognitive-behavioral model suggests that individuals with social anxiety may resort to social networks or video games as an avoidance strategy, leading to potential PIU (11). The compensatory Internet use theory posits that those with social anxiety use the Internet as a substitute for offline social and emotional connections, which exacerbates social anxiety symptoms and potentially leads to PIU (12). Furthermore, Social anxiety is estimated to affect 7%–13% of the general population, with a higher prevalence among adolescents and young adults. With studies suggesting that up to 15%–20% of college students experience symptoms of social anxiety (13, 14). Although a substantial body of research has established a positive correlation between social anxiety and PIU among adolescents and young adults, there is significant variability in the effect sizes reported across these studies (15–23).

While previous meta-analyses have demonstrated a positive association between PIU and social anxiety, they did not extend their subgroup analyses beyond developmental levels, or the results across different subgroups have not been consistent (24, 25). Differences in societal norms and technological advancements between different time periods or cultural contexts may lead to varying results in studies (24, 25). In addition, the use of different measurement tools may affect the correlation between PIU and social anxiety (26). Previous meta-analysis has also confirmed that the choice of scale can modulate the relationship between social anxiety and PIU (24). Furthermore, while social anxiety and PIU may have distinct manifestations across genders, meta-analytic subgroup effects regarding gender have shown inconsistent results (27, 28). The theory of gender and coping proposes that the way men and women deal with stressors may differ, influencing their vulnerability to developing PIU and social anxiety (29). In an effort to further elucidate the heterogeneity in previous meta-analyses, it is crucial to conduct subgroup analysis. In present study, we consider various factors, including publication year, cultural context, gender, and measurement tools used for PIU and social anxiety.

Although the exponential increase in the number of empirical studies exploring the relationship between PIU and social anxiety among student populations, to the best of our knowledge, no meta-analysis has been conducted to evaluate the overall effect of this relationship within adolescents and young adults. Thus, the current study aims to conduct a meta-analysis to explore the relationship between PIU and social anxiety among adolescents and young adults, with a specific objective to discern whether there are differences compared to other age groups from previous studies. Additionally, we also attempt to explore whether the strength of the relationship between PIU and social anxiety is moderated by effect of subgroups, with the aim of resolving inconsistencies observed in previous meta-analyses regarding subgroup analyses: (a) measurement tools used for PIU, (b) measurement tools used for social anxiety, (c) gender, (d) publication year, and (e) cultural context.

2. Materials and method

The current meta-analysis was conducted following the PRISMA (30) guidelines to ensure a rigorous and transparent methodology (see the checklist in Appendix). The PRISMA framework was used to guide the literature search, selection of articles, data extraction, and data synthesis. By adhering to PRISMA, the study aims to enhance the transparency and reliability of the research findings. The protocol of the current meta-analysis has been registered at PROSPERO [ID: CRD42022326313] (31).

2.1. Data collection

The present meta-analysis employed a comprehensive approach to identify relevant studies prior to September 7, 2023, utilizing multiple databases including Web of Science, PubMed, PsycINFO, Scopus, CNKI, and CQVIP (CQVIP and CNKI are Chinese databases, and the rest are English databases). Each database was queried using a distinct search formula, as provided in the Appendix. Two researchers independently screened the studies based on inclusion criteria. The collected articles were coded according to author information, year of publication, PIU measurement tool, social anxiety measurement tool country, sample size, male ratio, and age range of subjects.

2.2. Inclusion and exclusion criteria

To be eligible for inclusion in this meta-analysis, primary studies had to meet the following PICOS criteria (32): (1) population: studies that involved adolescents and young adults (14–24 years old) as participants, conducted in educational institutions; (2) intervention/exposure: studies that investigated the correlation between PIU and social anxiety using empirical analysis, excluding theoretical studies, review studies, meta-analyses, and case studies; (3) comparison: N/A (4) outcomes: studies that clearly reported sample size and correlation data between variables used in the study; and (5) study design: cross-sectional or longitudinal studies written in Chinese or English. Studies were excluded if they (a) investigated the other kinds of anxiety, (b) had a sample size of less than 30, and (c) were theoretical studies, review studies, meta-analyses, and case studies, (d) targeted on unique student groups such as left-behind children, (e) reported data using only regression analysis, structural equation modeling, and other statistical methods. The selection process

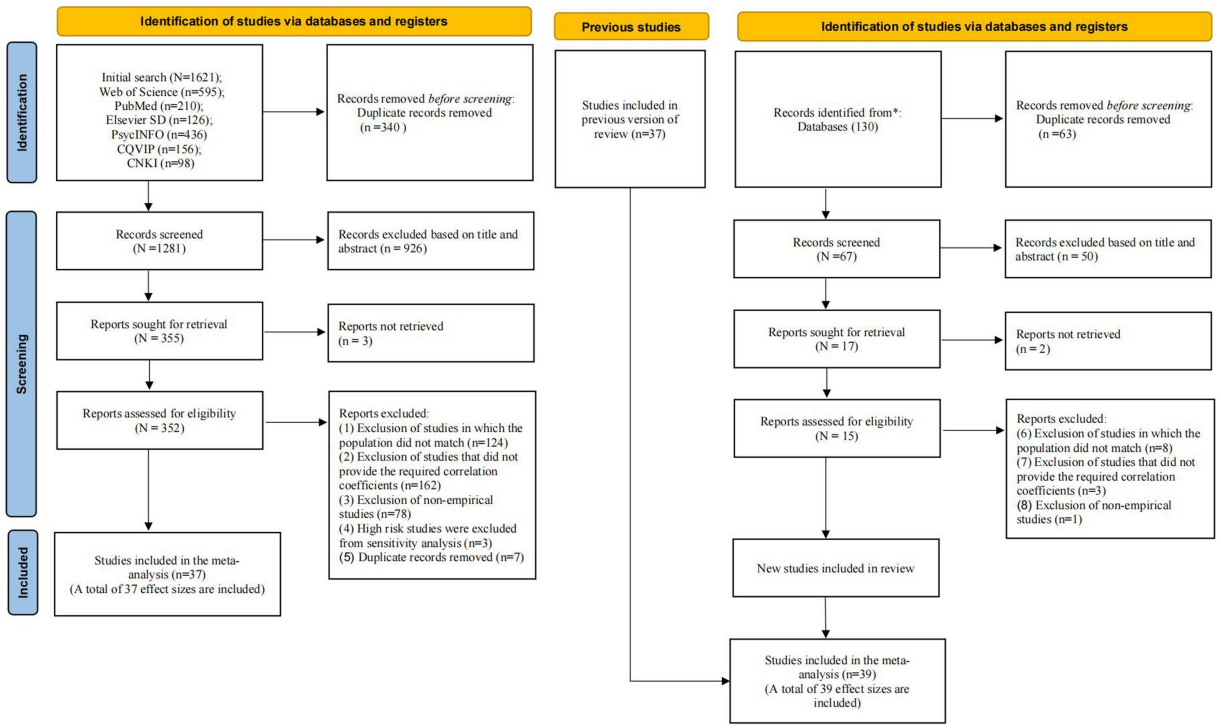

FIGURE 1
Flow chart process of study selection.

yielded 39 relevant studies that met the inclusion criteria and were included in the meta-analysis. See Appendix for the characteristics of included studies. The PRISMA flow chart of the systematic search is depicted in Figure 1.

2.3. Study coding and quality assessment

The coding criteria for the studies included in this meta-analysis were divided into two parts: the first part was independent coding of the effect sizes of PIU and social anxiety, and the second part was coding for the correlation of two keywords. The study of pertinent subgroups, such as the respondents' level of education, cultural background, gender, and measurement methods, was also included in the meta-analysis. The publication year was taken from the publication time of the article, the gender was coded according to the male ratio, and the measurement tools were coded according to the scale used. Cultural classifications are determined based on the dominant culture of the study's sample. The developmental stage is categorized into youth and adolescents, depending on whether the sample participants are adults (18–24 years old) or not (14–18 years old). To ensure the accuracy of the coding, 2 researchers coded the studies successively with an interval of more than 30 days between the two coding sessions, and the Kappa coefficient was tested to be 0.866, indicating the accuracy of the coding. However, in some cases, there were inconsistencies between the two coders. To resolve these discrepancies, the researchers have consulted with each other and a third-party was consulted to reach a consensus. The meta-analysis utilized *the quality assessment tool for observational cohort and cross-sectional studies* (33) for assessing the studies (Shown in Appendix). The use of this tool enabled a comprehensive evaluation of the included studies, thereby ensuring the rigor and validity of our findings.

2.4. Calculation of effect size

In meta-analysis, we often encounter situations where it is necessary to combine correlation coefficients from individual studies into an overall effect size. However, directly combining correlation coefficients poses two major challenges (34). Firstly, correlation coefficients do not follow a normal distribution and their distribution shape varies with the magnitude of the coefficient. Secondly, the variance of r coefficients is not constant but depends on their magnitude.

In the present study, prior to conducting meta-analysis using Stata 17.0 software, the extracted data were subjected to the following transformation according to the formula (34):

$$\text{a. Fisher's } Z = 0.5 \times \ln\left(1 + r \middle/ 1 - r\right)$$

$$\text{b. } vz = 1 \middle/ n - 3$$

$$\text{c. SEz} = vz^{0.5}$$

$$\text{d. Summary } r = e^{2z} - 1 \middle/ e^{2z} + 1$$

2.5. Data processing

Random-effects model is a common way to combine effect values. The random effects model assumes that the actual effects may differ across studies and that the different results are affected not only by random errors but also by different samples (35). In this study, we concluded that factors such as the year the study was conducted, the measurement tools for PIU and social anxiety may affect the relationship between problematic Internet use and social anxiety, and thus chose to combine the correlation coefficients in a random effects model. In addition, the test of heterogeneity will be used to determine the need for subgroup analyses and meta-regression, mainly by looking at the significance of the *Q*-test results and the I^2 value, and if the *Q*-test results are significant or the I^2 value is above 75%, the cause of heterogeneity should be explored as much as possible (36). The meta-analysis used the correlation coefficient *r* as an effect value, and Stata 17.0 as well as JASP 16.3 were used to pool effect values and analyze moderating effects. Publication bias is the preference for positive results, resulting in more positive results seen in publications (37), and was assessed in this study using a combination of funnel plots, Egger's regression coefficient test, and Begger's rank correlation test. The study also performed a sensitivity analysis (see Figure 2).

3. Results

3.1. Basic characteristics of included studies

The meta-analysis ultimately included 39 studies (39 effect sizes in total), involving a total of 38,333 subjects, spanning the years 2003 to 2023. The research samples included in the meta-analysis are from China, Iran, Colombia, Bangladesh, Italy, the United States, Switzerland, Turkey, Spain, France, Australia, and Germany. The age range of the participants was from 14 to 24 years old, and there was a total of 16,680 male participants. Basic information of the original studies included in the analysis were shown in Table 1.

3.2. Heterogeneity analysis

The results of the heterogeneity test revealed that the *Q* test for the effect value of the relationship between problematic network use and social anxiety was significant, with a *Q* value of 553.55 ($p < 0.001$) and a value of 93.1% for I^2, which exceeded the 75% rule (36), indicating that the results were heterogeneous.

3.3. Main effect estimation

The results showed that the overall correlation between PIU and social anxiety was 0.344 ($z = 16.384$, $p < 0.001$) with a 95% CI of (0.302, 0.385), as determined by Fisher's *Z* transformation of the correlation coefficients. According to the classification criteria for the size of the correlation, the correlation between the two was relatively strong and varied between 0.10 and 0.40 (65).

3.4. Subgroup analysis and meta-regression results

According to the results of the heterogeneity test, the random effects model was used to test the moderating effects of categorical variables, and the moderating effects of PIU measurement tools, social anxiety measurement tools and subjects' gender, cultural background and developmental level were analyzed, and the results are shown in Table 2. We also conducted the subgroup analyses with the type of databases (Chinese/English; shown in Appendix).

Meta-regression was conducted on publication year to investigate the sources of heterogeneity and publication year could explain the heterogeneity of meta-analysis [$t = 2.09$, $p = 0.044 < 0.05$; 95% CI (0.004.0.281); shown in Table 3].

3.5. Publication bias test

In testing for publication bias, the results were first examined by means of a funnel plot. As seen in Figure 3, the studies are more evenly distributed, which can out not indicate that studies targeting the relationship between the two may not have publication variance. For further publication bias testing, Egger's regression coefficient test with fail-safe *N* test was used.

Publication bias is less likely if fail-safe *N* is greater than $5K + 10$ (*K* represents the number of independent samples) (37). Fail-safe *N* results showed that $N = 42{,}768 > 5K + 10$. The results of the Egger regression coefficients showed that the intercept of the social anxiety regression equation did not reach a significant level ($z = -0.235$, $p = 0.814 > 0.05$) indicating that there was no significant publication bias in the current study. In conclusion, there was no significant publication bias in the current meta-analysis.

3.6. Sensitivity analysis

The meta-analysis tested several potential changes, including excluding certain studies, using different statistical methods, and evaluating potential publication bias, and the results consistently showed that the main conclusions remained unchanged. Therefore, we conclude that the meta-analysis results in this study are highly reliable and robust, suitable for informing decision-making and clinical practice in this field. The sensitive analysis table can be seen in the Appendix.

4. Discussion

The present meta-analysis revealed a significant positive correlation between PIU and social anxiety. The study also advances the current understanding of the relationship between PIU and social anxiety is moderated by effect of subgroups: measurement tools, publication year. Specifically, we found that publication year does in fact explain some of the heterogeneity observed across studies while previous meta-analysis have indicated that publication year does not moderate the relationship between PIU and social anxiety (25). The findings contribute to a more nuanced and comprehensive understanding of the association between PIU and social anxiety.

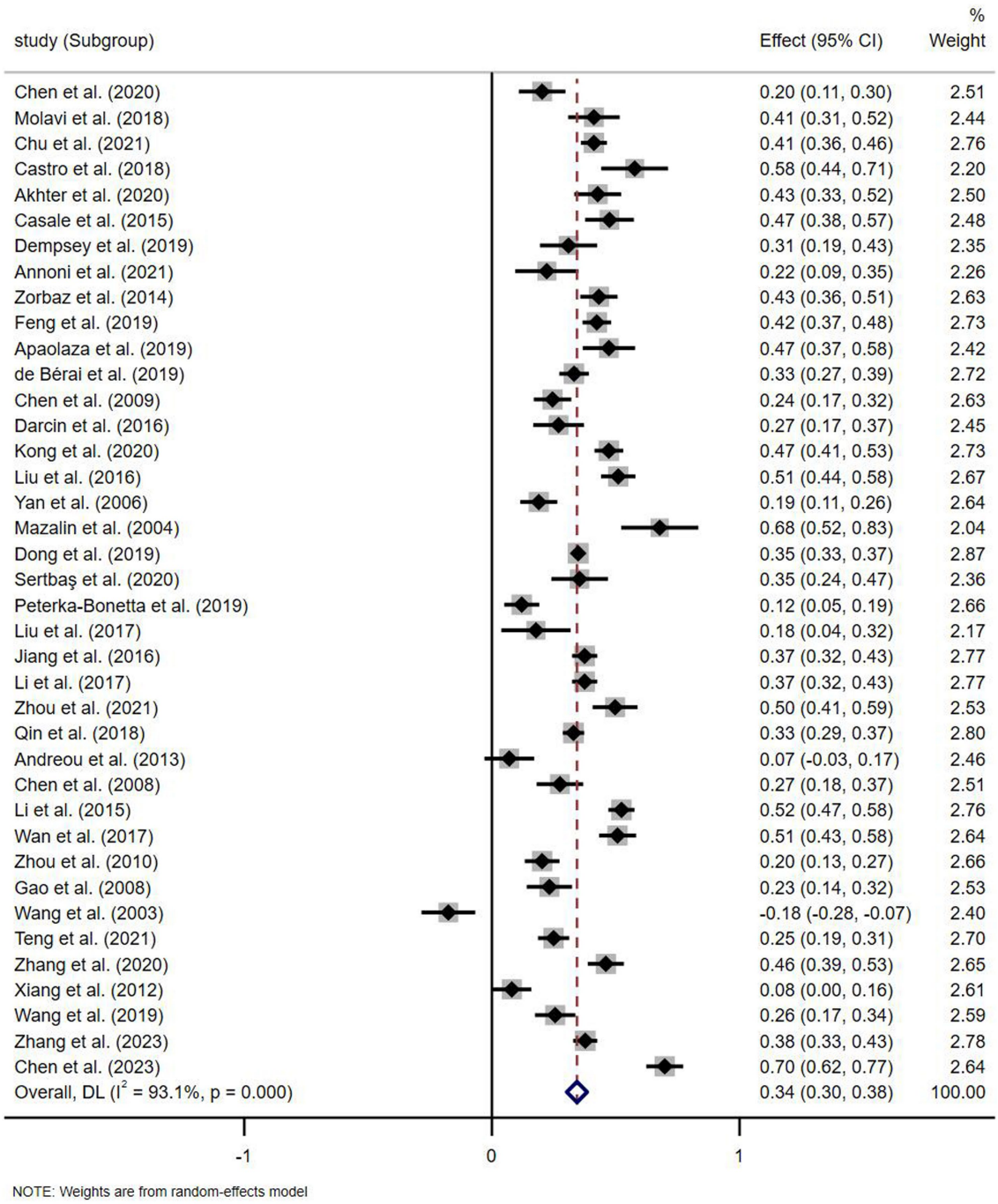

FIGURE 2
Forest plot of the association PIU and social anxiety.

4.1. Overall association between PIU and social anxiety

This study employed a meta-analytic methodology to investigate the association between PIU and social anxiety within the adolescent and young adult sample. The meta-analysis revealed a robust and positive correlation between PIU and social anxiety. The results suggest that individuals with elevated levels of PIU are more likely to report greater levels of social anxiety. The compensatory Internet use theory suggests that individuals with social anxiety may treat Internet as a "compensatory" mechanism for their lack of social and emotional connections in the offline world, which can lead to dependence on the Internet for social interactions, exacerbating symptoms of social anxiety and leading to PIU (12). Therefore, PIU has the potential to exert a detrimental influence on the social and emotional well-being of students, which in turn may culminate in academic obstacles.

In addition, among the 39 studies included in this meta-analysis, only one study reported a significant negative correlation between PIU and social anxiety among adolescents and young adults (28). Notably,

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TABLE 1 Basic information of the studies included in the meta-analysis.

1st author	Year	*N*	DL	*r*	Measurement (SA)	Measurement (PIU)	Nation	Male
Chen (18)	2020	437	YA	0.200	SPS	SNWAS	China	30%
Molavi (38)	2018	358	YA	0.390	SPI	IAT	Iran	44%
Chu (21)	2021	1,401	YA	0.390	SIAS	SNSATS	China	58%
Casale (39)	2018	214	YA	0.520	SIAS	IAT	Colombia	36%
Akhter (15)	2020	432	YA	0.403	SIAS	GPIUS2	Bangladesh	58%
Casale (39)	2015	400	YA	0.442	SIAS	GPIUS2	Italy	48%
Dempsey (20)	2019	291	YA	0.300	SIAS	FAS (Bergen)	USA	42%
Annoni (3)	2021	240	YA	0.218	SAS	SAS-SV	Switzerland	50%
Zorbaz (40)	2014	682	A	0.407	SAS	PIUSA	Turkey	48%
Feng (23)	2019	1,152	A	0.400	SAS	IAS	China	70%
Apaolaza (41)	2019	346	YA	0.440	SAS	CBS	Spain	48%
de Bérail (42)	2019	1,077	YA	0.320	SAS	IAT	France	27%
Chen (43)	2009	671	YA	0.240	SAS	CIAS	China	52%
Darcin (19)	2016	367	YA	0.142	SAS	BSPS	Turkey	38%
Kong (44)	2020	1,141	A	0.440	SAS	APMPUSQ	China	47%
Liu (45)	2016	800	YA	0.470	SAS	IRDI	China	49%
Biao-Bin (4)	2006	692	A	0.187	SAS	IAT	China	46%
Mazalin (46)	2004	161	YA	0.590	LSAS	IMS	Australia	58%
Dong (47)	2019	10,158	YA	0.335	LSAS	IAT	China	46%
Sertbaş (48)	2020	297	YA	0.340	LSAS	IAS	Turkey	50%
Peterka-Bonetta (49)	2019	773	YA	0.120	IAS	SPAI	German	39%
Liu (45)	2017	200	YA	0.176	IAS	MPATS	China	36%
Jiang (50)	2016	1,488	YA	0.358	IAS	MPATS	China	37%
Li (51)	2017	1,488	YA	0.358	IAS	MPATS	China	37%
Zhou (52)	2011	468	YA	0.460	IAS	MPATS	China	56%
Qin (53)	2018	2056	A	0.318	IAS	IRDI	China	34%
Andreou (17)	2013	384	A	0.070	IAS	IAT	Greek	46%
Chen (54)	2008	437	YA	0.268	IAS	IAT	China	54%
Li (55)	2015	1,380	A	0.48	IAS	IAT	China	52%
Wan (56)	2017	695	YA	0.468	IAS	IAT	China	44%
Zhou (57)	2010	787	YA	0.2	IAS	IAT	China	30%
Gao (58)	2008	461	YA	0.228	IAS	IAT	China	46%
Wang (28)	2003	329	YA	0.174	IAS	IAT	China	51%
Teng (59)	2021	970	YA	0.244	IAS	FAS (Bergen)	China	26%
Zhang (60)	2020	725	YA	0.43	IAS	IAT	China	39%
Xiang (61)	2012	613	YA	0.08	IAS	IAT	China	61%
Wang (62)	2019	578	A	0.250	SAS	MPATS	China	57%
Zhang (63)	2023	1,626	A	0.36	DASS-21	SAS-SV	China	31%
Chen (64)	2023	694	A	0.603	SAD	MPATS	China	50%

DL, developmental level; YA, young adults; A, adolescents; SPS, social phobia scale; SNWAS, social network use and anxiety scale; SIAS, social interaction anxiety scale; SNSATS, social network site addiction scale; GPIUS2, generalized problematic internet use scale 2; FAS (Bergen), Bergen Facebook addiction scale; SAS-SV, social anxiety scale for adolescents-short version; PIUSA, problematic internet use scale for adolescents; CBS, cyber bullying scale; BSPS, brief social phobia scale; APMPUSQ, adolescent pathological mobile phone use scale questionnaire; IRDI, internet-related distress scale; LSAS, Liebowitz social anxiety scale; IMS, Internet-motivation scale; IAS, internet addiction scale; SPAI, social phobia and anxiety inventory; MPATS, mobile phone addiction tendency scale; IMS, internet-motivation scale; SPI, social phobia inventory; DASS-21, depression, anxiety, stress scales-21; SAD, social avoidance and distress scale; SA, social anxiety.

TABLE 2 Results of subgroup analysis.

Subgroup	Heterogeneity		Type	*k*	Effect size and 95% interval			Test of null (2-tail)	
	Q_B	*df*			*r*	LL	UL	*Z*	*p*
PIU measurement	20.97***	4	IAT	17	0.298	0.230	0.367	8.547	<0.001
			MPATS	5	0.346	0.269	0.424	8.760	<0.001
			GPIUS2	2	0.450	0.382	0.518	12.935	<0.001
			FAS	2	0.263	0.209	0.318	9.314	<0.001
			Others	13	0.398	0.319	0.476	9.893	<0.001
Social anxiety measurement	10.81*	4	SIAS	5	0.433	0.368	0.499	12.886	<0.001
			SAS	11	0.350	0.283	0.418	12.886	<0.001
			IAS	16	0.272	0.193	0.352	6.708	<0.001
			LSAS	3	0.444	0.284	0.604	5.446	<0.001
			Others	4	0.423	0.231	0.616	4.308	0.003
Developmental level	0.04	1	Adolescents	8	0.333	0.292	0.373	7.277	<0.001
			Young adults	31	0.330	0.284	0.376	14.006	<0.001
Culture	0.17	1	Eastern	26	0.338	0.289	0.386	13.610	<0.001
			Western	13	0.358	0.273	0.444	8.213	<0.001
Gender	0.04	1	M > F	14	0.351	0.246	0.455	6.586	<0.001
			F > M	25	0.340	0.300	0.380	16.384	<0.001

PIU, problematic internet use; M, male; F, female. IAT, internet addiction test; MPATS, mobile phone addiction tendency scale; GPIUS2, generalized problematic internet use scale 2; FAS, Facebook addiction scale; SIAS, social interaction anxiety scale; LSAS, Liebowitz social anxiety scale.

TABLE 3 Meta-regression of publication year.

_ES	Coefficient	Std. err.	*t*	*p*	95% CI
Year	0.014	0.006	2.09	0.044	(0.004, 0.281)
_cons	−28.397	13.7567	−2.06	0.046	(−56.271, −0.523)

Year, publication year.

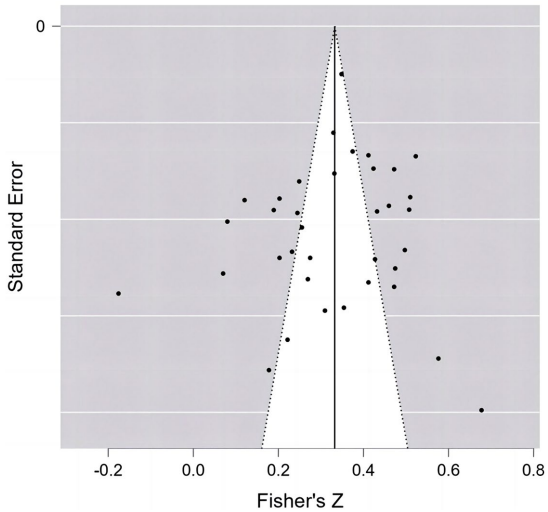

FIGURE 3
Funnel plot of the association PIU and social anxiety.

the number of participants with PIU in that study was significantly less than that of similar studies conducted. This result may be attributed to several factors. First, the issue of sampling bias must be considered, as some studies were conducted online, and in such cases, individuals with a greater interest in Internet use may be more likely to participate. In contrast, the aforementioned study was conducted offline and limited to schools with restricted Internet access. Second, the study's age was relatively dated, and people spent less time online than today.

4.2. Heterogeneity with subgroups

The present meta-analysis utilized subgroup analysis to explore the potential effects of publication year, measurement tools for PIU and social anxiety, cultural background, and gender on the association between PIU and social anxiety. The findings revealed that while the subgroup analysis of measurement tools for PIU and social anxiety and publication year demonstrated a significant effect, the subgroup analysis of cultural background, and gender did not yield significant effects.

4.2.1. Meta-regression analysis of publication year

The current meta-analysis indicated a significant meta-regression effect of publication year on the correlation between PIU and social anxiety among adolescents and young adults while previous meta-analysis found that early studies on PIU and social anxiety may have had

a biased sample leading to publication years not explaining heterogeneity (25). Specifically, the strength of the correlation has increased over time. This finding observed variation could be attributed to a multitude of factors. These may include the advent of new assessment tools for PIU and social anxiety, heightened identification of at-risk populations, alterations in Internet activities, and advancements in accessibility and technology of online platforms, among others.

4.2.2. Subgroup analysis of measurement tools for PIU and social anxiety

The finding regarding the moderating effect of measurement tools on the relationship between PIU and social anxiety highlights the importance of careful tool selection in research, this was inconsistent with the findings of previous meta-analyses (24, 66). One plausible explanation for these inconsistencies lies in the ongoing absence of consensus regarding the precise definitions and criteria for PIU and social anxiety. The lack of consensus around the definition and criteria of PIU and social anxiety has resulted in no universally accepted measurement tool, may leading to inconsistencies in findings (67, 68).

4.2.3. Subgroup analysis of cultural context

Through subgroup analysis, we found that the cultural context may contribute to reduced heterogeneity of the sample. While previous research has suggested that cultural background may moderate the relationship between PIU and social anxiety within adult sample (24), the present study did not find a significant moderating effect of cultural background. One possible explanation for this discrepancy is the difference in the sample populations used in present studies. As Figure 4 shows, the present study mainly focused on a sample of students from a single cultural background (Chinese). Current research may suggest that contemporary adolescents and youth exhibit more "global" characteristics, indicating that cultural differences may be less pronounced than they were before. The lack of significant moderating effects of cultural background in the present study suggests that the relationship between PIU and social anxiety may be relatively stable across different cultural contexts.

4.2.4. Subgroup analysis of gender

We also found that the gender may contribute to reduced heterogeneity of the sample through subgroup analysis. Previous research has suggested that there may be differences in the preferences of males and females for gaming and social applications, which could affect their use of mobile devices and their risk of potential addictive behaviors. For example, a study found that males were more likely to use game applications with competitive and adventurous characteristics, while females were more likely to use social applications (69). However, many other studies have not found a direct relationship between gender and PIU (70, 71). This suggests that while males and females may have different preferences and behaviors, gender itself is not a key factor influencing the relationship between PIU and social anxiety.

4.2.5. Subgroup analysis of developmental level

We found no significant difference between adolescents and youth in the relationship between PIU and social anxiety. This may be due to the pervasive use of internet across these age groups, and the relatively similar social contexts they are embedded in, such as school or university environments where Internet use is prevalent and often necessary for both academic and social purposes. It is possible that the similar exposure to online environments and the comparable pressures they face in these stages of their lives lead to no significant variance in the PIU-social anxiety relationship across these groups.

Previous research has revealed a significant difference between adolescents and the adult group (including middle-aged and older individuals) (25). This could be attributed to the fact that adults, particularly those in middle and older age, may have different internet usage habits compared to younger individuals. Adults may use the Internet more for practical purposes such as work, information

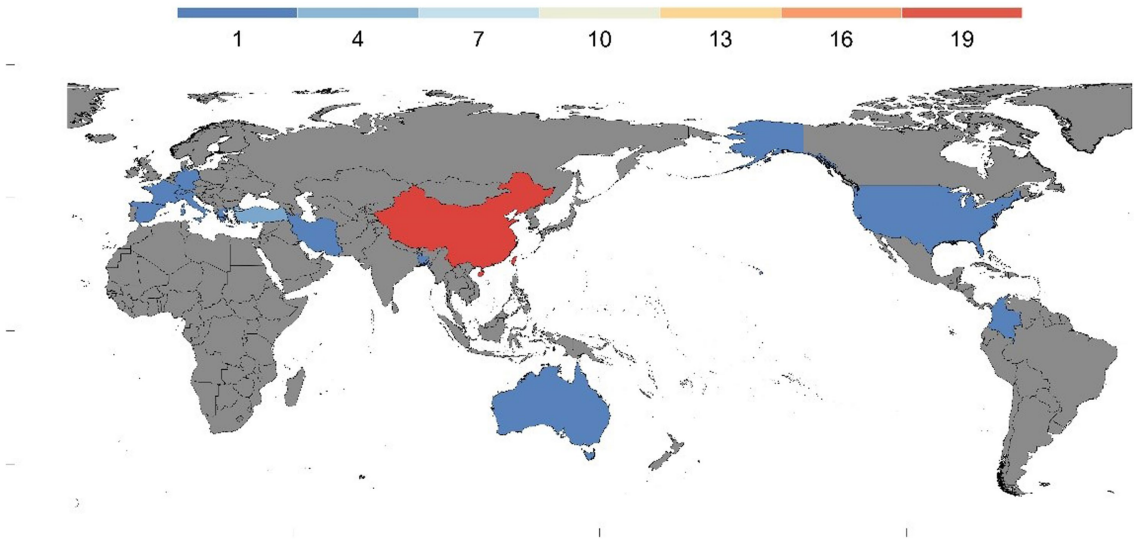

FIGURE 4
Sample distribution map.

seeking or maintaining social connections, rather than for leisure or as a primary social outlet. Moreover, the level of digital literacy and the role of the Internet in daily life can also differ significantly between these age groups, which can contribute to the differential impacts of PIU on social anxiety.

5. Limitations and prospects

The principal merits of the meta-analysis are its revelation of the association between PIU and social anxiety in the adolescent and young adult population and the meta-analysis has also identified heterogeneous explanatory factors that were not previously reported in the literature, while also providing novel insights for cross-cultural research in this field. Nevertheless, the study possesses several limitations. For starters, the prime demerit is undeniably that the predominantly cross-sectional nature of the literature, limiting our ability to infer causality. Longitudinal designs would allow researchers to identify whether PIU precedes social anxiety, or if social anxiety leads to PIU, or if the relationship is bi-directional. Understanding these dynamics could be crucial for developing effective preventative measures and interventions. The second noteworthy demerit is the method of conducting a survey, The majority of the studies included in our meta-analysis collected data through online questionnaires. A potential limitation of this method lies in the self-selection bias inherent to online research. Future research should aim to address this limitation by adopting more diverse data collection methods. For instance, offline methods such as in-person interviews or paper-and-pencil questionnaires can be used to include individuals who might be less inclined to participate in online research.

Given that college students comprise the primary study subjects in the field, subsequent research in the field should include more representative sampling methods, such as stratified sampling or random sampling, can be employed to ensure the inclusion of diverse demographic groups, including individuals with varying levels of internet use and interest.

6. Conclusion

The meta-analysis utilized the random effects model to quantitatively analyze the association between PIU and social anxiety among adolescents and young adults (age range: 14–24 years old). The results revealed a significant positive correlation between PIU and social anxiety, indicating that social anxiety is a predictor of PIU development in this age group. Subgroup analysis and meta-regression results identified significant differences in the relationship between PIU and social anxiety based on the publication year and measurement tools used. However, no significant differences were found with regards to developmental level, gender or cultural context.

Author contributions

HD: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Writing – original draft, Writing – review & editing. BC: Project administration, Software, Writing – review & editing. QS: Visualization, Writing – review & editing.

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Conflict of interest

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Supplementary material

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Trajectories of depressive symptoms in young and middle-aged men who have sex with men with new HIV-diagnosis: a 1-year prospective cohort study in Beijing, China

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Introduction: Due to the sexual orientation and HIV diagnosis, young and middle-aged men who have sex with men (MSM) with new HIV-diagnosis may experience more depressive syndromes and face greater psychological stress. The study explored trajectories of depressive symptoms of young and middle-aged MSM within 1 year after new HIV-diagnosis and analyze the related factors.

Methods: From January 2021 to March 2021, 372 young and middle-aged MSM who were newly diagnosed as HIV-infection were recruited in two hospitals in Beijing. Self-rating Depression Scale was used to measure the participants' depressive symptom in 1st month, 3rd month, 6th month, 9th month and 12th month after HIV diagnosis. The latent class growth model was used to identify trajectories of the participants' depressive symptoms. Multinomial logistic regression was used to analyse factors related with the trajectories.

Results: Three hundred and twenty-eight young and middle-aged MSM with new HIV-diagnosis completed the research. Depressive symptom in 328 young and middle-aged MSM was divided into three latent categories: non-depression group (56.4%), chronic-mild depression group (28.1%), and persistent moderate–severe depression group (15.5%). The participants assessed as non-depression (non-depression group) or mild depression (chronic-mild depression group) at the baseline were in a non-depression state or had a downward trend within one-year, and the participants assessed as moderate and severe depression (persistent moderate–severe depression group) at the time of diagnosis were in a depression state continuously within 1-year. Multinomial logistic regression analysis showed that, compared with the non-depression group, monthly income of 5,000 ~ 10,000 RMB (equal to 690 ~ 1,380 USD) was the risk factor for the chronic-mild depression group, and self-rating status being fair/good and self-disclosure of HIV infection were protective factors for the persistent moderate–severe depression group while HIV-related symptoms was the risk factor.

Conclusion: Depressive symptoms in young and middle-aged MSM is divided into three latent categories. Extra care must be given to young and middle-aged MSM assessed as moderate or severe depression at the time of HIV-diagnosis,

especially to those who had poor self-rating health status, did not tell others about their HIV-infection and experienced HIV-related symptoms.

KEYWORDS

HIV infection, men who have sex with men, young adult, middle-aged adult, depression, latent class growth analysis

1. Introduction

The MSM (men who have sex with men) population refers to men who have sex with men, gay men, and some bisexual men who exhibit homosexual behavior (1). MSM are a high-risk group for HIV infection due to their multiple sexual partners and low condom use (2). The proportion of newly diagnosed HIV-positive people whose disease was transmitted by gay behaviors increased from 9.1% in 2007 to 23.3% in 2019 (3). HIV infection is a stressful and traumatic experience which has a devastating impact on the mental health of patients, especially in MSM who have already been under some pressure due to their sexual orientation. HIV-positive MSM are a vulnerable social group susceptible to prejudice and discrimination (4). They are more prone to suffer mental health problems, including depression, than the general or other HIV-positive populations. Studies have shown that the incidence of depression in HIV-positive MSM ranged from 21.2 to 92.5% (5–7). Depression led to adverse health outcomes, such as accelerated disease progression, decreased quality of life, and increased mortality (8, 9).

For HIV-positive patients, ages between 18 and 50 are usually considered as young and middle ages (10). The majority of MSM are at this age range when they are diagnosed with HIV (11). Young and middle-aged people are the main labor force in society and are also in the active period of marriageable age and sexual life. However, for MSM, sexual orientation has affected their marriage status to some extent (12). Since traditional Chinese culture regards unmarried or childless people as losers and unfilial (especially in the marriageable age of young and middle-aged people), young and middle-aged MSM face greater psychological pressure, and the incidence of depression may be higher (4, 13). When HIV infection is confirmed, the depression will be further aggravated (14). Thus, the young and middle-aged MSM with new HIV-diagnosis deserve further study.

Increasing experience and gradual changes in life may affect the degree of emotional despondency of young and middle-aged MSM, causing depression to vary at different stages after HIV-diagnosis. It was reported that the status of depression in MSM changed over time, especially in the first year after HIV diagnosis (15). Therefore, measuring their depression once cannot reflect the overall state of depression in any given period. However, most studies on depressive symptom among MSM with HIV-infection are cross-sectional (16–18). In the limited longitudinal studies conducted on trends of depressive symptom of MSM with HIV-infection, findings are mixed. The level of depression was increased in 24 months (19), declined (15, 20) or increased first and then decreased in 12 months (21). The MSM included in these studies experienced different course of HIV-infection. None of them targeted young and middle-aged MSM newly diagnosed with HIV-infection. The discrepancy in these studies may be caused by differences in sample characteristics, particularly the different stages of HIV-infection. Moreover, these longitudinal studies reported group averages of depression, without considering the possible effects of individual differences.

Bonanno, a clinical psychologist, pointed out that individuals show different trajectories of change in their psychological state after a traumatic experience (22). For HIV-positive men, Kelso-Chichetto et al. (23) used group-based trajectory models to identify a four-group depressive symptoms pattern for them (low: 34%; moderate: 34%; high: 22%; severe: 10%). Bengtson et al. (24) also found four depressive symptoms trajectories for HIV-Infected men (low: 61%; mild/moderate: 14%; rebounding: 5%; improving: 13%; severe: 7%). But none of these studies take the MSM into account. Given the special nature of newly diagnosed HIV-positive young and middle-aged MSM, it is necessary to identify trajectories of depressive symptoms over time for them and to define characteristics of individuals within distinct trajectories, so as to adopt targeted interventions. Thus, this study aimed to identify distinct trajectories of depressive symptoms and explore clinical profiles related to the classifications among young and middle-aged MSM within the first year after HIV-diagnosis.

2. Materials and methods

2.1. Sample

This was an observational cohort study. Young and middle-aged MSM with new HIV-diagnosis were recruited at two specialized-hospitals of infectious diseases in Beijing from 1st January 2021 to 31st March 2021, and then followed them up to 12 months. HIV-positive patients are recommended to return to the hospital at 3-month intervals for follow-up in China, so participants who enrolled in this cohort study were investigated in the first month (no more than 30 days), 3rd month, 6th month, 9th month, and 12th month after being HIV-diagnosed. The last follow-up was conducted on March 31, 2022.

Participants were MSM diagnosed as HIV-infection within the past 30 days, 18 ~ 50 years old, MSM transmission (self-reported). Those who had other serious diseases or had taken psychoactive medication during the past month were excluded. Criteria for discontinuing follow-up were: (1) unexpected event occurred and could not continue to participate in the study; (2) times of not

Abbreviations: MSM, Men who have Sex with Men; SDS, Self-rating Depression Scale; LCGM, Latent Class Growth Model; GMM, Growth Mixture Models; AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; aBIC, size-adjusted BIC; LMR, Lo–Mendell–Rubin likelihood ratio test; BLRT, Bootstrapped likelihood ratio test.

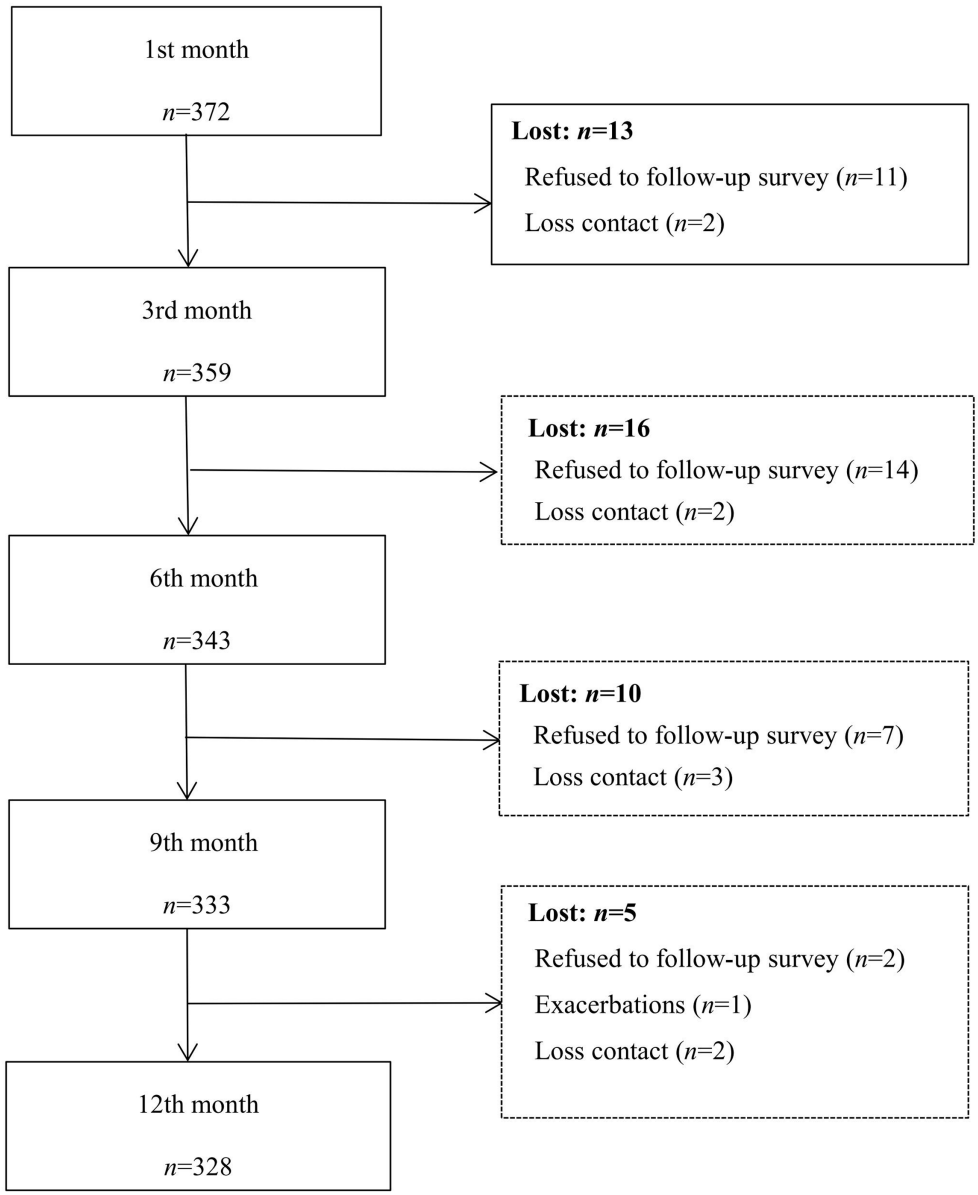

FIGURE 1
Participation of young and middle-aged MSM in five times survey.

participating in follow-up survey >1. Questionnaires with more than 10% of missing items, or a logical error, or completion time less than 10 min were regarded as invalid. Finally, 328 participants completed the entire process. Figure 1 showed the participants enrollment process. This study was approved by a specific Medicine Ethics Committee (blinded for peer review).

2.2. Measurements

2.2.1. Self-rating depression scale

Depressive symptoms were measured by the Chinese version of Self-rating Depression Scale (SDS) (25, 26), a self-assessment scale to measure the degree of depression, which consists of 20 items using a 4-point Likert scale according to the frequency of depressive symptom over a 2 week period, from '1'(no or little time) to '4'(most or all of the time), and 10 items are reverse scored. The total score ranges from 20 to 80, with a higher score indicating more severe depressive symptom. For Chinese populations, a cut-off standard score of 53 (total scale score by 1.25 is the China's standard score) has been recommended to screen for depression, and depression is divided into three levels: 53–62 is mild depression, 62–72 is moderate depression, ≥72 is severe depression (27). Cronbach's α coefficient and split-half reliability of the SDS are more than 0.8 (28). The Cronbach'α coefficient was 0.858 in this study. SDS was collected at both baseline and four times follow-up.

2.2.2. Socio-demographic information sheet

The socio-demographic information sheet was used to collect the participants' socio-demographic characteristics in the first month

after HIV-diagnosis. It includes marital status, occupation status, educational background, living alone or not, have children or not, household location (urban/rural), monthly income (RMB), medical payment, self-rating health status, sexual orientation (homosexual, heterosexual, bisexual), and self-disclosure of HIV infection or not.

2.2.3. Clinical information sheet

Clinical characteristics were collected from the medical record in the first month after HIV-diagnosis. These included CD_4^+ counts (an important indicator to observe the efficacy of anti-AIDS treatment), HIV-related diseases (syphilis, condyloma acuminate, tuberculosis etc.), and HIV-related symptoms (continuous fever for over one-month, continuous cough for over one-month, etc.).

2.3. Data collection

The first survey was conducted face-to-face for all the participants. Researchers explained the purpose and content of the study in a case-management room in the hospital. After giving the consent, the participants filled in questionnaire. When the patients had questions about the questionnaire, the researchers provided appropriate explanations. The questionnaire was retrieved on the spot after completing it. Due to the pandemic of COVID-19, 193 participants did not visit hospitals for next four times follow-up. Therefore, they completed the survey either by phone or online (Wenjuanxing - a platform providing functions equivalent to Amazon Mechanical Turk). Participants received a gift (10 RMB, equal to 1.4 USD) in appreciation for their participation after each questionnaire.

2.4. Statistical analyses

Data analysis was conducted by SPSS 26.0, SAS 9.4 and Mplus 7.0. Statistical analysis of socio-demographics and clinical data was performed using descriptive statistical methods (median, number, and percentage). For comparison of the baseline characteristics of participants who completed the five-time surveys and those who dropped out, non-continuous variables were analyzed using Chi-square tests, whereas continuous variables were analyzed using Mann–Whitney tests.

The latent class growth model (LCGM) assumes that growth parameters are homogeneous within a latent subgroup, making it an extension of growth mixture models (GMM), so the data were analyzed using GMM and LCGM in our study. The model setting begins with a baseline model (single-category growth model), and then gradually increases the number of categories of the model. The best fitting model was chosen by comparing the fit indices among the different categories of models, the realistic meaning or interpretability, and relevant theories. Fit indices used to evaluate the model included: (1) information evaluation index, Higher values for Akaike Information Criterion (AIC), bayesian information criterion (BIC), and sample size-adjusted BIC (aBIC), all of which indicate better fit into the data for the model; (2) the Lo–Mendell–Rubin likelihood ratio test (LMR) and Bootstrapped likelihood ratio test (BLRT), which show a superior model for given k latent subgroups when comparing model-data fit to a model with k-1 latent subgroup; and (3) entropy, which is used to evaluate the classification accuracy of the model. The entropy coefficient has a value between 0 and 1, and the closer the value to 1, the more accurate the classification is. The entropy was calculated with values of $\geq$0.80, indicating more than 90% were assigned the correct classification (29). The fit indices and substantial meaning were used to determine the final model classification (30). Finally, the effect of participants' socio-demographic and clinical data on the different track of depression was examined by using multiple classification logistic regression analysis.

3. Results

3.1. Sample characteristics

A total of 423 young and middle-aged MSM with new HIV-diagnosis were recruited, 51 refused to participate in the survey for personal reason and 372 completed baseline survey. Finally, 328 (88.17%) completed four follow-up surveys (Figure 1).

There were no significant differences in most baseline factors between 328 patients who completed the follow-up survey and 44 patients who did not, except for marital status, have child or not, and have HIV-related diseases. Participants lost to follow-up were more likely to be unmarried, without children and with HIV-related diseases than those who completed the study.

All the 328 participants who completed five follow-up surveys were on average 30.5 years old (19 ~ 50 years old), the majority were single (80.8%), lived alone (41.5%), had no children (89.6%), were employed (70.4%), had education background of college or higher (75.3%), and more than half (70.4%) reported a monthly income of 5,000 RMB (equal to about 690 USD) or more. Hundred and ninety-three patients registered permanent residence as urban. 42.7% used self-paid medical treatment, and more than half (54.9%) did not disclose their infection status to others within a month of HIV diagnosis. Only 119 participants (36.3%) reported good self-rating health status, and 229 participants (69.8%) reported same-sex sexual orientation. Regarding disease-related characteristics, the average of CD_4^+ cell counts was 333.35 cell/mm^3, 245 patients (74.7%) had no other associated disease and 49.7% of them had HIV-related symptoms.

3.2. Trajectories of depressive symptoms

Taking the SDS scores of participants at five time points as the observation index, 328 patients were included in the model statistics. First, LCGM was used to fit the data, and the model was configured as a time-parameter free estimate model, with categories 1 to 5 extracted successively. When the number of extracted categories was increased from 1 to 3, the p-values of LMR and BLRT were significant ($p < 0.05$), the values of AIC, BIC, and aBIC became smaller, and the entropy value was always greater than 0.8, which led to the conclusion that the retention of three categories was supported by the analysis results. When the number of categories was increased further, the entropy value remained greater than 0.8, the p-value of BLRT remained significant, the value of BIC continued to decrease, and no minimum value was observed. As a result, the steep slope graph test was used to sort the value of BIC from small to large, and there was a significant inflection point when the category was 3, and the LMR $p = 0.079$ when taking four categories, implying that three categories

should be chosen at this time. The *p*-value of LMR was 0.029 when the number of categories was five, but the variability between the conditional category probabilities was greater, with a minimum value of 0.009, corresponding to a *n* (case) of 3; however, the sample's representativeness may be limited.

The model was set to GMM and re-fitted to determine an even better fitting model. When three categories were retrieved, the BIC value was the smallest, entropy was greater than 0.80, and the *p*-values of both LMR and BLRT reached a significant level, which indicated that three categories remained. Comparing the three categories preserved by LCGM and GMM in further detail, the GMM classification accuracy index entropy value was lower than that of LCGM, and the conditional probabilities of the three categories retained by LCGM were more plausible. Considering the aforementioned indicators and the interpretability of the data, the three best LCGM categories were selected, with 185 cases in Group 1, 92 instances in Group 2, and 51 cases in Group 3, representing 56.4, 28.1, and 15.5% of the total cases, respectively. Table 1 compares the outcomes of LCGM and GMM model fitting evaluations, and Figure 2 depicts the growth trend.

The designation was based on the trajectory and features of each observation in Figure 2. Figure 3 shows the predicted and observed mean SDS for each trajectory group. Group 1 was no depression in 1 month after diagnosis ($I = 40.166$, $p = 0.001$) and exhibited a declining trend at the following four time-points ($S = -1.096$, $p = 0.001$), so it was named non-depression group. Group 2 was mild depression 1 month after diagnosis ($I = 52{,}402$, $p = 0.001$) and showed a decreasing tendency at the following four time-points ($S = -0.917$, $p = 0.015$), so it was named chronic-mild depression group. Group 3 had moderate-to-high depression levels in 1 month after diagnosis ($I = 63.968$, $p = 0.001$) and remained stable at the following four time-points ($S = -0.100$, $p = 0.825$), so it was named persistent moderate–severe depression group.

3.3. Factors of potential categories of depressive trajectories

According to the results of univariate analysis, the three trajectory categories of depression in the young and middle-aged MSM with new HIV-diagnosis were statistically different in monthly income, self-rating health status, self-disclosure of HIV infection, and HIV-related symptoms, respectively (Table 2 and Table 3).

Multicategorical logistic regression analysis was conducted with the statistically significant variables in the univariate analysis as independent variables, the potential category of depression as the dependent variable, and the non-depression group as the reference category. Logistic regression analysis showed that, compared with the non-depression group, monthly income of 5,000 ~ 10,000 RMB (equal to 690 ~ 1,380 USD) was the risk factor for the chronic-mild depression group. Self-rating fair/good health and self-disclosure of HIV infection were protective factors for the persistent moderate–severe depression group, and HIV-related symptoms was the risk factor for this group (Table 4).

4. Discussion

Depression is the most prevalent negative emotion in HIV-positive MSM (31), especially in the first year after HIV diagnosis (15). This study fully considered the heterogeneity of negative emotion groups in newly diagnosed HIV positive MSM, and used LCGM to describe the development process of depression in HIV-positive young and middle-aged MSM, and to describe the growth track of potential categories of depression and from the diagnosis stage to 1 year after diagnosis. This is the first study to describe depressive symptom trajectories among young and middle-aged MSM with new HIV-diagnosis in China. We found that within 1 year after the diagnosis, the depression of young and middle-aged MSM with newly diagnosed HIV-positive had group heterogeneity, and their depression could be divided into three potential groups: non-depression group, chronic-mild depression group and persistent moderate–severe depression group.

This study found that the track of depressive symptoms of young and middle-aged MSM within one-year after HIV-diagnosis is different in terms of severity and stability, which is consistent with previous studies for people living with HIV (23, 32). The classification result of this study is consistent with Bonanno's (22) view that psychological changes in groups after experiencing trauma follow different trajectories. The non-depression group, the chronic-mild

TABLE 1 Comparison of model fit evaluation results for different categories.

Model		*K*	AIC	BIC	aBIC	entropy	*P*		Class probability
							LMR	BLRT	
LCGM	1C	7	12846.21	12872.77	12850.56	—	—	—	1
	2C	10	11979.76	12017.69	11985.98	0.933	<0.001	<0.001	0.345/0.655
	3C	13	11785.31	11834.62	11793.38	0.879	0.025	<0.001	0.281/ 0.564/0.155
	4C	16	11685.27	11745.96	11695.21	0.839	0.079	<0.001	0.137/0.378/0.225/0.259
	5C	19	11630.77	11702.84	11642.57	0.866	0.029	<0.001	0.137/0.009/0.381/0.216/0.256
GMM	1C	10	11657.11	11695.04	11663.32	—	—	—	1
	2C	13	11619.47	11668.78	11627.55	0.767	0.004	<0.001	0.274/0.726
	3C	16	11598.76	11659.45	11608.69	0.833	0.049	<0.001	0.720/0.244/0.0365
	4C	19	11594.94	11667.01	11606.74	0.871	0.025	0.102	0.280/0.677/0.006/0.037
	5C	22	11592.75	11676.20	11606.41	0.809	0.283	0.308	0.604/0.006/0.040/0.149/0.201

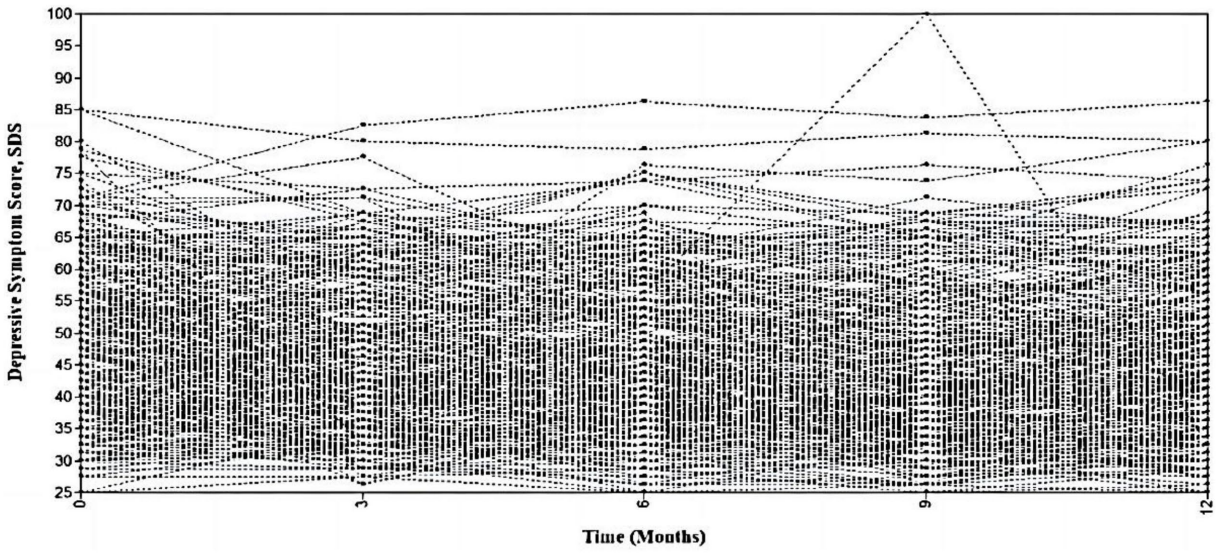

FIGURE 2
The SDS scores for trajectory observation from all individuals.

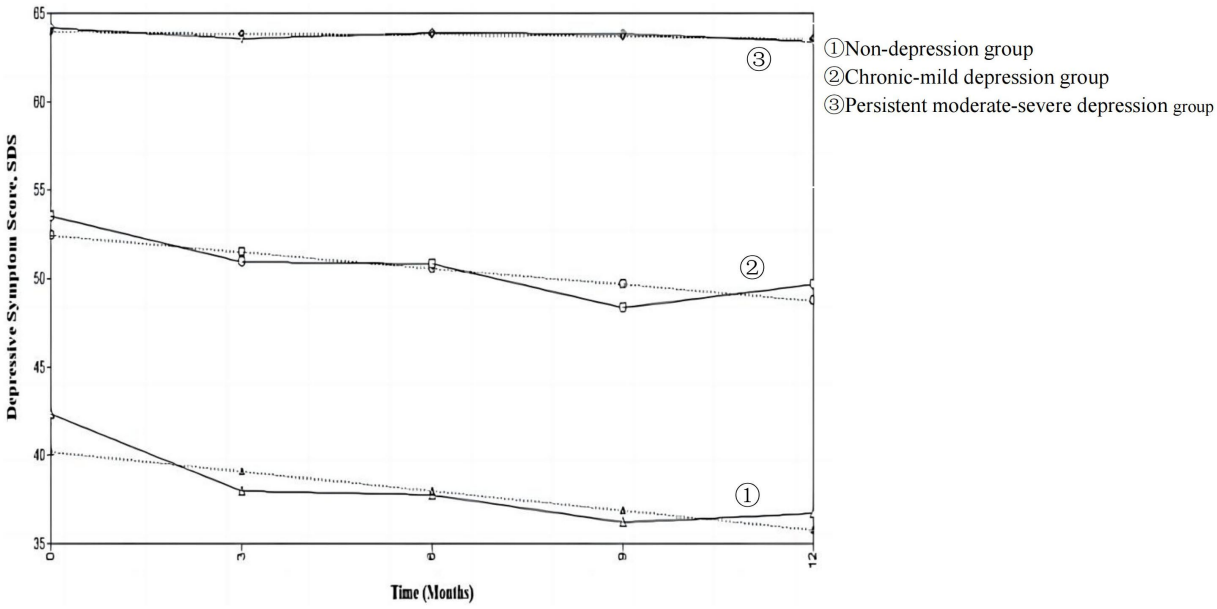

FIGURE 3
Predicted and observed mean SDS for each trajectory group. Solid lines are mean SDS on rate data, dashed lines are predicted mean SDS based on trajectory modeling.

depression group, and the persistent moderate–severe depression group in our study are consistent with the recovery trajectory, the resilience trajectory, and the chronic dysfunction trajectory in Bonanno's view, respectively. Among the three latent category groups, more than half of the patients (56.4%) were in the non-depression group, which is similar to the results from a longitudinal study on previous HIV-positive patients (32, 33), but higher than the study of Heckman et al. (34) in 105 older adults with HIV infection (31% non-depression) and Larsen et al. (35) in 824 HIV-positive pregnant women (38.5% with persistent no/mild depressive symptoms). The young and middle-aged MSM included in this study were mostly employed (70.43%), single or without children in marital status (89.63%), with high monthly income [70.43% over 5,000 RMB/month (equal to 690 USD)]. With the implementation of the "Four frees and one care" policy in China from 2003, anti-viral drugs, counseling and testing are provided free of charge to more and more patients with AIDS in China, and AIDS patients with difficulties in life are included in the scope of government assistance. This policy is one of the most

TABLE 2 Results of univariate analysis of categories of depressive trajectories in young and middle-aged MSM with new HIV-diagnosis (socio-economic variables).

Variable	Non-depression group $N = 185$	Chronic-mild depression group $N = 92$	Persistent moderate–severe depression group $N = 51$	χ^2	P
	n(%)	n(%)	n(%)		
Marital status					
Single	151(81.6)	73(79.3)	41(80.4)	1.248	0.870
Married	22(11.9)	13(14.1)	5(9.8)		
Divorced/widowed	12(6.5)	6(6.5)	5(9.8)		
Having children					
Yes	24(13.0)	8(8.7)	2(3.9)	3.909	0.142
No	161(87.0)	84(91.3)	49(96.1)		
Occupation status					
Employment	132(71.4)	66(71.7)	33(64.7)	6.151	0.188
Unemployment	26(14.1)	14(15.2)	14(27.5)		
Student	27(14.6)	12(13.0)	4(7.8)		
Educational background					
High school or below	39(21.1)	30(32.6)	12(23.5)	4.435	0.109
College or higher	146(78.9)	62(67.4)	39(76.5)		
Living alone					
Yes	71(38.4)	40(43.5)	25(49.0)	2.079	0.354
No	114(61.6)	52(56.5)	26(51.0)		
Household location					
Urban	107(57.8)	55(59.8)	31(60.8)	0.190	0.909
Rural	78(42.2)	37(40.2)	20(39.2)		
Monthly income (RMB / USD)					
< ¥ 5,000 ($690)	56(30.3)	22(23.9)	19(37.3)	13.725	0.008
¥ 5,000 ~ 10,000 ($690 ~ 1,380)	68(36.8)	53(57.6)	21(41.2)		
> ¥ 10,000 ($1,380)	61(33.0)	17(18.5)	11(21.6)		
Medical payment method					
Medicare-paid	105(56.8)	53(57.6)	20(39.2)	6.530	0.163
Self-paid	76(41.1)	36(39.1)	28(54.9)		
Other	4(2.2)	3(3.3)	3(5.9)		
Self-rating health status					
Poor	12(6.5)	8(8.7)	23(45.1)	69.257	<0.001
Fair	85(45.9)	58(63.0)	23(45.1)		
Good	88(47.6)	26(28.3)	5(9.8)		
Sexual orientation					
Heterosexual	15(8.1)	9(9.8)	5(9.8)	2.220	0.696
Homosexual	134(72.4)	59(64.1)	36(70.6)		
Bisexual	36(19.5)	24(26.1)	10(19.6)		
Self-disclosure of HIV infection					
Yes	94(50.8)	39(42.4)	15(29.4)	7.778	0.021
No	91(49.2)	53(57.6)	36(70.6)		

powerful policy measures for AIDS prevention and control in China. It may to some extent alleviate the stress of AIDS patients, thereby alleviating depression.

Among 328 young and middle-aged MSM with new HIV-diagnosis, 28.1% were in the chronic-mild depression group, which indicated that about one-fourth of patients suffered from mild

TABLE 3 Results of univariate analysis of categories of depressive trajectories in young and middle-aged MSM with new HIV-diagnosis (clinical information).

Variable	Non-depression group $N = 185$	Chronic-mild depression group $N = 92$	Persistent moderate–severe depression group $N = 51$	χ^2/F	P
	n(%)	n(%)	n(%)		
HIV-related diseases					
Yes	40(21.6)	27(29.3)	16(31.4)	3.117	0.211
No	145(78.4)	65(70.7)	35(68.6)		
HIV-related symptoms					
Yes	74(40.0)	49(53.3)	40(78.4)	24.270	<0.001
No	111(60.0)	43(46.7)	11(21.6)		
CD_4^+ counts (cells/mm^3)	346.00 ± 21.19	335.39 ± 14.26	303.11 ± 188.75	1.319	0.517

TABLE 4 Unordered logistic regression analysis of categories of depression trajectories in young and middle-aged MSM with new HIV-diagnosis.

Factor	β	SE	Wald χ^2	P	OR	95% CI
Chronic-mild depression group versus non-depression group						
Constant	−0.635	0.557	1.299	−0.254	—	—
Monthly income (RMB/USD)						
< ¥ 5,000 ($690)	Ref	Ref	Ref	Ref	—	—
¥ 5,000 ~ 10,000 ($690 ~ 1,380)	0.632	0.321	3.877	0.049	1.882	1.003 ~ 3.532
> ¥ 10,000 ($1,380)	−0.438	0.382	1.312	0.252	0.646	0.305 ~ 1.365
Persistent moderate–severe depression group versus non-depression group						
Constant	0.388	0.572	0.462	0.497	—	—
Self-rating health status						
Poor	Ref	Ref	Ref	Ref	—	—
Fair	−1.631	0.457	12.725	<0.001	0.196	0.080 ~ 0.480
Good	−3.119	0.617	25.526	<0.001	0.044	0.013 ~ 0.148
Self-disclosure of HIV infection						
No	Ref	Ref	Ref	Ref	—	—
Yes	−1.116	0.388	8.248	0.004	0.328	0.153 ~ 0.702
HIV-related symptoms						
No	Ref	Ref	Ref	Ref	—	—
Yes	1.124	0.414	7.375	0.007	3.078	1.367 ~ 6.929

Ref, reference group.

depressive symptom within 1-month after HIV-diagnosis. However, with the deepening of understanding HIV-infection and experiencing treatment effects, the MSM's depression symptom decreased and finally became non-depression, which is similar to the findings of Mylona et al. (36) in a study on breast cancer patients within 1 year of diagnosis, suggesting that the young and middle-aged MSM with mild-depression at the time of HIV-positive diagnosis may be able to self-regulate while confronting the stressful event. The challenge model (a type of psychological resilience model) put forward by Garmezy et al. (37) suggests that when an individual encounters adversity of moderate intensity, it will stimulate the potential and adaptability of the individual to cope with stressful events and will further increase its adaptability after the individual has successfully responded.

In this study, 15.5% of new HIV-diagnosis young and middle-aged MSM were in the persistent moderate–severe depression group, which is similar to the "persistently high depression" subgroup (12.7%) of HIV-positive patients using LCGM by Gunzler et al. (33). This finding implied that within a year of receiving an HIV-diagnosis, a small percentage of young and middle-aged MSM experience chronically elevated depression. HIV-positive MSM with depression had lower levels of antiviral drug adherence (38), immunity (39), survival and quality of life (40, 41) compared to those without depression. Depression also increased the prevalence of high-risk sexual behavior (42). It is suggested that medical staff should give psychological care to minimize depressive symptom in young and middle-aged MSM with moderate–severe depression at onset of HIV diagnosis.

Our study revealed that the new HIV-diagnosis young and middle-aged MSM whose self-rating health was fair/good were less likely to experience persistent moderate–severe depression. They are more confident in their physical state and undergo follow-up antiviral therapy, hence decreasing the likelihood of HIV-related diseases and HIV-related symptoms in life (43), resulting in a low likelihood of unpleasant feelings.

Our study found that self-disclosure of HIV infection predicted the non-depression trajectory. The young and middle-aged MSM who disclosed their HIV status were more likely to be in the non-depression group. Studies have demonstrated that disclosing one's HIV status to others is a protective factor against depressive symptoms in patients (44, 45). The sexual culture of MSM is relatively open and diversified, and HIV-positive MSM are more likely to disclose their infection status to close friends, regular partners, and family members to obtain more emotional support (46, 47).

We also found that the probability of sustained high-level depression in young and middle-aged MSM with HIV-related symptoms is 3.078 times higher than that in those without HIV-related symptoms. The patients with HIV-related symptoms experienced the discomfort caused by HIV infection and fear of further deterioration of the disease, so they had a relatively high incidence of depressive symptoms. Notably, clinical indicators such as CD_4^+ count had no effect on patients in different depression categories in this study. This might be related to the MSM's stable decrease in CD_4^+ count after treatment, resulting in a lower perception of this indicator by the MSM.

There are several limitations in the study. Firstly, the samples in the study were from Beijing, one of the first-tier cities in China. Most of the participants had higher education and higher monthly income, thus, the representativeness of the sample is limited. Secondly, since all data were self-reported, social desirability bias may have contributed to underreporting. Thirdly, similar worded items at five time-points may have influenced the young and middle-aged MSM to reply consistently regardless of real experience. However, by collecting data five times, we can capture a spectrum of depression status of young and middle-aged MSM after HIV-diagnosis to aid the design of target interventions. Finally, this study considered the influence of MSMs' demographic and clinical characteristics on the trajectory of depressive change, but did not include social factors such as social support and HIV-related stigma. Next, we will combine social factors to comprehensively explore the factors that affect the trajectory of depression changes.

5. Conclusion

This study fully considered the group heterogeneity of depression in young and middle-aged MSM with new HIV-diagnosis, and identified three different change tracks: the non-depression group, the mild-depression group and the persistent moderate–severe depression group. The monthly income, self-rating health status, whether to tell others about HIV-infection, and whether having HIV-related symptoms affected depression track categories of the patients. The findings are helpful for medical staff understand the trend of depression in young and middle-aged MSM with different characteristics within one-year after HIV-diagnosis, and to identify individuals with a moderate–severe depression to take target interventions.

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 humans were approved by Beijing Ditan Hospital Capital Medical University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

XL, YL, and JH designed the work. XL, YL, JH, XB, and FL collected the data. XL and YL analyzed and interpreted the data. XL drafted the manuscript. YL, KL, and JH revised the manuscript. All authors contributed to the article and approved the submitted version.

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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

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Identifying the communication of burnout syndrome on the Twitter platform from the individual, organizational, and environmental perspective

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Addressing the escalating prevalence of burnout syndrome, which affects individuals across various professions and domains, is becoming increasingly imperative due to its profound impact on personal and professional aspects of employees' lives. This paper explores the intersection of burnout syndrome and human resource management, recognizing employees as the primary assets of organizations. It emphasizes the growing importance of nurturing employee well-being, care, and work-life balance from a human resource management standpoint. Employing social media analysis, this study delves into Twitter-based discourse on burnout syndrome, categorizing communication into three distinct dimensions: individual, organizational, and environmental. This innovative approach provides fresh insights into interpreting burnout syndrome discourse through big data analysis within social network analysis. The methodology deployed in this study was predicated upon the enhanced Social Media Analysis based on Hashtag Research framework and frequency, topic and visual analysis were conducted. The investigation encompasses Twitter communication from January 1st, 2019, to July 31st, 2022, comprising a dataset of 190,770 tweets. Notably, the study identifies the most frequently used hashtags related to burnout syndrome, with #stress and #mentalhealth leading the discussion, followed closely by #selfcare, #wellbeing, and #healthcare. Moreover, a comprehensive analysis unveils seven predominant topics within the discourse on burnout syndrome: organization, healthcare, communication, stress and therapy, time, symptoms, and leadership. This study underscores the evolving landscape of burnout syndrome communication and its multifaceted implications for individuals, organizations, and the broader environment, shedding light on the pressing need for proactive interventions. In organizations at all levels of management, the concept of burnout should be included in the value philosophy of organizations and should focus on organizational aspects, working hours and work-life balance for a healthier working environment and well-being of employees at all levels of management.

KEYWORDS

burnout, communication, environmental factors, human resources management, individual factors, organizational factors, social media analysis, Twitter

1. Introduction

Burnout syndrome has long been an increasingly discussed topic, affecting more professions and fields. While psychology primarily addresses its solution and prevention, it is crucial to recognize that prevention requires a multidisciplinary approach. Therefore, human resource management (HRM) must address this issue as well. From the original conception by Freudenberger (1974), who defined burnout as a state of physical exhaustion resulting from an individual's professional activity, it is evident that the connection to HRM is relevant. Burnout syndrome is characterized by signs and symptoms stemming from complete energy depletion and deficiencies in resources or strength (Correia et al., 2021).

From HRM perspective, it is essential to note that specific jobs and job roles have a higher prevalence of burnout syndrome associated with elevated stress levels. Numerous studies have examined this correlation. Golonka et al. (2019) also highlight that burnout is linked to overlapping effects of other syndromes and disorders, such as depression and anxiety. Additionally, individual characteristics like neuroticism contribute to the propensity for burnout. Whether the burnout syndrome is independent remains unclear (Kurzthaler et al., 2017). However, as Bedrnová (2012) pointed out regarding HRM, we must acknowledge that burnout syndrome is not solely caused by emotional exhaustion, which can also stem from personal life issues. It is also characterized by depersonalization, feelings of alienation or detachment from oneself, and low personal achievements. Employee development plans, performance appraisals, workplace relationships, employee support, and perceptions of job and role can all be linked to burnout syndrome (Bedrnová, 2012).

Burnout is a complex phenomenon influenced by various factors at different levels. Understanding the causes of burnout can help organizations and individuals develop effective interventions and prevention strategies (McCormack and Cotter, 2013; Green et al., 2014). Therefore, creating a work environment that promotes employee well-being, provides adequate resources and social support, and recognizes and values employee contributions is essential. Understanding factors affecting burnout is vital to care employees' psychosocial well-being, organizational effectiveness, and consent health (Maslach, 2003). According to Maslach (2003), future studies should examine additional factors at the client, provider, and organizational level variables to determine their relative impact on burnout.

Pilař et al. (2021) recognize significant research potential in the data generated through active and passive digital traces left by social network users, for whom this form of communication has become an integral part of their daily lives. People's communication on social media, and consequently the content of the data conveyed through these platforms, encompass a wide range of facts, opinions, ideas, and emotions (Steinert and Dennis, 2022). The influence of emotion and the concept of feedback expectancy on social networking has been addressed by Stsiampkouskaya et al. (2021). In their research, Burbach et al. (2020) investigated whether or not a user of online social networks disseminates information and found that the type of network has only a weak influence on the dissemination of content, while the kind of message has an evident effect on how many users receive the message. Radwan (2022) addressed the topic of cultural identity (the set of memories, impressions, ideologies, ideas, etc.), that maintain people's civilizational identity. His research focused on recognizing the influence of social media on selected components of cultural identity demonstrated a high rate of change in cultural identity with social media use. Stieglitz and Dang-Xuan (2013) point out that this vast data collection provides valuable grounds for communication analysis and research. In line with the growing interest in social media communication, this study explicitly investigates the communication surrounding burnout syndrome from the perspective of the Twitter platform users.

In today's digital era, where social media has emerged as a primary mode of communication and emotional expression, it becomes imperative to comprehend how individuals communicate about critical topics, such as burnout syndrome. Although numerous studies focus on burnout in psychology and HRM (e. g. Schaufeli et al., 2009; Maslach and Leiter, 2016; Russell et al., 2020; González-Rico et al., 2022; Storti et al., 2023), only some delve deeply into the discourse surrounding burnout on platforms like Twitter (Harren et al., 2021; Black et al., 2022). This study offers a novel insight into the communication dynamics of burnout syndrome by investigating how individuals, organizations, and broader societal contexts articulate this phenomenon on Twitter. Recognizing these communication patterns can empower organizations to understand better and address their employees' needs and may serve as a foundation for future preventive strategies. The growing importance of addressing burnout in today's fast-paced, digitally connected world makes it a compelling issue deserving of our attention. Given the rising prevalence of burnout across various professions and sectors, this study is timely and essential.

This paper aims to identify communication focused on burnout syndrome on the Twitter from the perspective of individual, organizational and environmental factors, bringing a new perspective to the burnout syndrome communication research field.

This study addresses several key questions: How do the Twitter users discuss the topic of burnout and which hashtags do they employ when communicating about burnout? What is the frequency of the hashtag usage concerning burnout? Which topics are most discussed in the context of burnout syndrome on the Twitter? To which factors affecting burnout syndrome do the communicated hashtags relate? Lastly, how does this communication on the Twitter impact HRM and employee well-being?

Thus, our study extends beyond the confines of social media, seeking to understand how communication on Twitter can influence HRM practices and, consequently, employee well-being. In this way, we strive to provide actionable insights that can lead to more effective strategies for combating burnout and enhancing the quality of life in contemporary workplaces. In light of these considerations, our study is a pertinent exploration into the world of burnout syndrome communication on Twitter, offering valuable insights and implications for researchers, practitioners, and individuals alike.

2. Theoretical background

Edú-Valsania et al. (2022) reported that Graham Greene was the first author to use the term burnout in his novel "*A Burnt-Out Case*," published in 1960. Subsequently, the term was introduced into the psychological domain by Freudenberger (1974), who described burnout as a state of exhaustion, fatigue, and frustration resulting from professional activities that fail to yield anticipated outcomes.

Maslach (1976) further contributed to the understanding of burnout, defining it as a gradual process of fatigue, cynicism, and diminished commitment among social service employees. Later, Maslach and Jackson (1981) defined burnout as a psychological syndrome characterized by emotional exhaustion, depersonalization, and reduced professional efficacy. According to Edú-Valsania et al. (2022), it is crucial to conceptualize burnout as a syndrome, wherein a syndrome is understood as a collection of symptoms and signs that coexist and clinically define a particular condition separate from others. In their study, Edú-Valsania et al. (2022) provide a comprehensive overview of the most up-to-date and empirically supported explanatory theories of burnout. Specifically, the paper details the following theories: (1) social cognitive theory, (2) social exchange theory, (3) organizational theory, (4) structural theory, (5) job demands-resources theory, and (6) emotional contagion theory.

While consensus is yet to be reached regarding the conceptualization and measurement of burnout, there is some agreement that it is not a one-dimensional occupational phenomenon and that exhaustion represents a core component of burnout (Demerouti and Bakker, 2022). One widely recognized tool for assessing burnout syndrome is the Copenhagen Burnout Inventory (CBI), which evaluates personal, work-related, and client-related burnout across various job domains. The CBI defines burnout as the state of physical and mental burnout and exhaustion, specifically focusing on the burnout phenomenon itself (Kristensen et al., 2005).

2.1. Types of burnout

Personal burnout refers to how individuals experience physical and psychological fatigue and exhaustion, irrespective of their occupational status. The Copenhagen Burnout Inventory (CBI) includes a subscale measuring personal burnout. This 6-item subscale comprises questions such as "*How often do you feel tired?*," "*How often do you think: 'I cannot take it anymore'*" and "*How often do you feel worn out?*" (Kristensen et al., 2005, p. 200). Notably, leaders play a multifaceted role in fostering resilience within organizations. They should personally invest in resources that enhance their strength to mitigate the risk of personal burnout (McEwen, 2022). Another type of burnout (one part of CBI) is *work-related burnout*. The work-related burnout has also been identified as a contributing factor to absence from work due to long-term illness and, thus, the loss of productivity (Hallsten et al., 2011). Work-related burnout is common and detrimental to employees in many industries (Lam et al., 2022). In addition, work-related burnout resulting from chronic stress is well-documented (Maslach and Jackson, 1984; Kristensen et al., 2005; Shirom et al., 2009; Gray-Stanley and Muramatsu, 2011; Maslach and Leiter, 2016; Wood et al., 2020). The third type of burnout is CBI's *client-related burnout* category, referring to the degree of physical and psychological fatigue and exhaustion that a person perceives concerning work with clients (Kristensen et al., 2005). The client is a general term covering people such as patients, students, teachers, children, etc., who receive service (i.e., service recipients) from people who provide the service (i.e., service providers). The items of client-related burnout precisely assess the connection between fatigue and people-centered work (Chin et al., 2018).

High emotional exhaustion, cynical attitudes, and a diminished sense of personal accomplishment at work characterize *professional burnout*. Recent changes in healthcare delivery have also raised concerns that provider burnout may worsen if increased patient care and administrative demands outpace resources (Shanafelt et al., 2015). Indeed, according to a national study by Shanafelt et al. (2015), burnout among physicians compared to the general population increases. Over the past two decades, a growing body of evidence has suggested that personality may significantly contribute to the development of burnout (Alarcon et al., 2009). Further, Jin et al. (2015), in their study on teachers, identified teacher personality as one of the most influential predictors of burnout.

Occupational burnout can have adverse consequences not only at an individual level (e.g., physical and mental health problems) (Suñer-Soler et al., 2013) but also at an organizational level (e.g., absenteeism, poor performance at work, misjudgments and errors, job turnover) (Ochoa, 2018). From an individual and an organizational perspective, preventing occupational burnout has been viewed as the best approach to deal with this phenomenon (Borysiewicz, 2010). In addition, according to Žutautienė et al. (2020), primary prevention of occupational burnout should be considered a public health priority worldwide.

Chronic stress can lead to burnout in professions that involve working with people. Burnout syndrome is characterized by persistent physical and emotional exhaustion and behavioral issues (Suyi et al., 2017). Workplace behavior changes may be the first noticeable signs in a team or collective. However, the effects of burnout extend beyond individual behavior and can be observed at the organizational level, impacting employee performance, communication, teamwork, and meeting deadlines. In addition to stressors, burnout is influenced by demographic factors and the level of social support. Several studies have addressed social support as a preventive measure against burnout syndrome (Halbesleben, 2006; González-Morales et al., 2012). These studies have highlighted the organizational dimension of burnout, with employees closely perceiving how burnout affects their colleagues, emphasizing the crucial role of the work environment in its development. HRM has recently highlighted the quality of working relationships and employee care. Research indicates that certain professions, such as healthcare, are more susceptible to burnout syndrome (Manna et al., 2022).

The concept of quality has expanded to include the non-work component of life, leading to the emergence of the work-life balance theory and various theoretical concepts that consider both work and personal aspects of life (Agrawal et al., 2022). Work-life quality comprises two fundamental components: achievement and positive experiences (enjoyment). These components counterbalance to negative influences associated with burnout syndrome (Aloulou et al., 2023). In the 1980s, Freudenberger and Torkelsen (1984); Freudenberger and North (1985) described the progression of burnout syndrome. The incubation period for burnout cannot be uniformly defined as it depends on various external circumstances and individual personality factors (Amir et al., 2018).

2.2. The multifaceted and complex causes of burnout

Burnout syndrome is a prevalent problem that affects many employees, especially those in high-stress jobs. Burnout can lead to reduced job satisfaction, decreased productivity, and increased

absenteeism, harming individual and organizational performance (Maslach and Leiter, 2016). The causes of burnout are multifaceted and complex, which involve a combination of individual, organizational, and environmental factors (McCormack and Cotter, 2013; Green et al., 2014; Galletta et al., 2016), as shown in the Figure 1.

Individual factors such as personality traits, coping skills, and work style have been found to contribute to burnout (Hakanen et al., 2006; McCormack and Cotter, 2013; Green et al., 2014; Rees et al., 2019). According to Maslach and Leiter (2016), employees with a high workload, long hours, and little control over their work are more likely to experience burnout. Thus, low levels of job autonomy, increased work demands, and job insecurity are more susceptible to burnout (Hakanen et al., 2006). One significant cause of burnout is a work-life imbalance, which arises when work demands interfere with the employee's personal life (Greenhaus and Allen, 2011). Greenhaus and Allen (2011) pointed out that employees with long commuting times, inadequate childcare, or other family responsibilities may experience difficulties balancing their work and personal life, leading to stress and burnout.

Organizational factors such as inadequate resources, job control, social support, and low levels of job satisfaction have also been linked to burnout (McCormack and Cotter, 2013; Green et al., 2014; Maslach and Leiter, 2016). Maslach and Leiter (2016) pointed out that a lack of job control, inadequate resources, and poor communication can lead to chronic stress and burnout. Bakker et al. (2014) have found that employees who work in organizations with high job demands and low levels of social support are more likely to experience burnout. Research has also found that employees who do not receive adequate recognition or support from their supervisors are more likely to experience burnout (Halbesleben and Buckley, 2004). According to Hakanen et al. (2006), lacking organizational support, such as inadequate resources, low pay, and job insecurity, can lead to burnout.

Additionally, a lack of recognition, feedback, and opportunities for growth can contribute to feelings of depersonalization and emotional exhaustion (Maslach and Leiter, 2016). Bakker et al. (2014) stressed that employees who feel isolated, disconnected, or unsupported by their colleagues or supervisors may experience high levels of burnout. The lack of control or autonomy in the workplace can lead to frustration, helplessness, and reduced job satisfaction (Maslach and Leiter, 2016). Moreover, work-related conflict and incivility (such as bullying, harassment, and discrimination) can also contribute to burnout (Cortina et al., 2013).

Environmental factors can also contribute to burnout. For instance, changes in the work environment, such as restructuring, downsizing, or mergers, can cause uncertainty and ambiguity, leading to increased job stress and burnout (Brough et al., 2005; McCormack and Cotter, 2013; Galletta et al., 2016; Rees et al., 2019). In addition, economic instability, political turmoil, and natural disasters can also have significant effects (Shanafelt et al., 2020). As Shanafelt et al. (2020) pointed out, employees who work in high-risk or hazardous environments, such as healthcare employees, firefighters, or law enforcement officers, may experience chronic stress and burnout due to exposure to traumatic events and emotional strain. For example, healthcare employees during the COVID-19 pandemic have experienced high levels of burnout due to the stress of working in a high-risk environment and the emotional toll of caring for sick patients (Shanafelt et al., 2020). Further, the blurring of boundaries between work and personal life due to technological advances and the increasing use of information and communication technology can lead to work overload and difficulties achieving a work-life balance, resulting in burnout (Hakanen et al., 2006). Clarifying our understanding of environmental factors associated with burnout can help agencies and leaders work to effectively implement organizational interventions (Green et al., 2014).

3. Materials and methods

The methodology deployed in this study was predicated upon the enhanced Social Media Analysis based on Hashtag Research (SMAHR) framework as outlined by Pilař et al. (2021). This SMAHR framework-driven analytical procedure encompassed four distinct stages, as depicted in the Figure 2.

3.1. Data acquisition

The primary objective of this stage was to collect data from the Twitter featuring the hashtag #burnout. The timeframe for this data collection spanned from January 1st, 2019, to July 31st, 2022, with the Twitter Application Programming Interface (API) serving as the mechanism for extraction (Platform Developer, 2022). The Twitter API v2 was utilized to garner the data in question, facilitated by the Tractor software (Tractor, 2023). This software was specifically employed to download tweets encapsulating the hashtag #burnout. A substantial accumulation of 190,770 tweets from 71,873 unique Twitter users was extracted throughout this period. The dataset compiled encompasses the entirety of tweets, inscribed with the hashtag #burnout, posted by users on the Twitter within the predefined observational period.

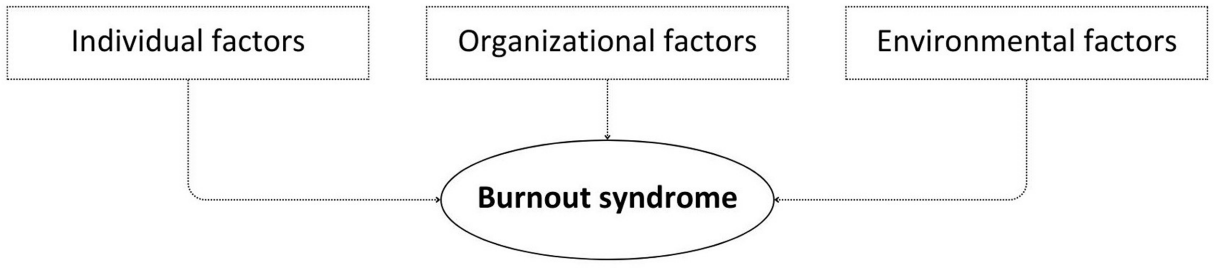

FIGURE 1
The multifaceted and complex causes of burnout: interplay of individual, organizational, and environmental factors. Source: Own elaboration (2023).

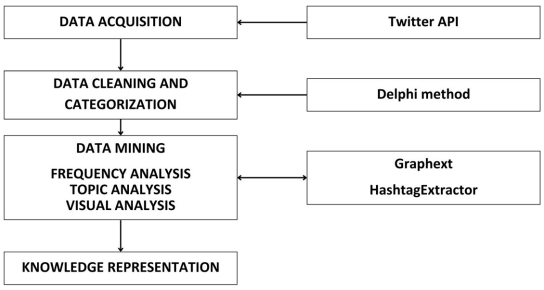

FIGURE 2
Four steps of the social media analysis based on the SMAHR framework for the hashtag research. Source: Own elaboration (2023).

3.2. Data cleaning and categorization

In the initial phase, the data was subjected to a cleaning process. Out of the 76,971 unique hashtags associated with the #burnout hashtag, the 80 most frequently used ones were chosen for further analysis (see Table 1). However, the 14 hashtags were excluded based on their content, explicitly removing illogical or unclear ones (see Table 2 for more details).

After the cleaning phase, the categorization of the 66 remaining hashtags was realized. The Delphi method was used to categorize the hashtags and provide a new perspective from expert HRM practitioners on the various aspects influencing burnout syndrome. It is a collaborative approach that facilitates structured and anonymous communication among experts to reach a consensus (Brady, 2015). This approach's essential advantage is avoiding confrontation between the experts (Okoli and Pawlowski, 2004). Three independent HRM experts participated in the categorization and classified the hashtags into individual, organizational, and environmental factors. Another HRM expert subsequently reviewed the results, incorporating feedback into the analysis, leading to further discussions and finalizing the results.

3.3. Data mining

This stage's objective is to extract pertinent and valuable information from the abundant data produced by users across various social media platforms.

3.3.1. Frequency analysis

This analysis is intended to pinpoint the hashtags most frequently used. By leveraging the Hashtag Extractor software (Pilař et al., 2021), all the hashtags were extracted from individual Tweets. The count of the particular hashtags was computed by importing them into the Gephi 0.9.2 software (Bastian et al., 2009).

3.3.2. Topic analysis

This method is utilized to discern the principal subjects or themes conveyed within a large dataset, such as posts on social media platforms. In intricate networks, like those of social media, specific nodes (e.g., hashtags or words) exhibit more interconnectedness among themselves than with the remaining components of the network. It is feasible to discern topics based on the clusters of the particular hashtags. The objective of this phase was to delineate the thematic structure of discussions related to burnout on the Twitter. Unlike frequency analysis, topic analysis was based on complete tweets (not merely hashtags). Graphext software (Graphext, 2023) was employed for this analysis. To dissect the community structure of our network, Graphext applied a modified variant of the Louvain algorithm (Blondel et al., 2008). The network was established based on the interconnectivity of individual words within the tweet. The Louvain algorithm implements an iterative procedure of allocating nodes to clusters to optimize a performance metric known as modularity. This metric measures the comparative density of edges within clusters as opposed to those between clusters. The quantity of distinct communities within the dataset was determined as follows:

$$\Delta Q = \left[\frac{\sum_{in} + 2k_{i,in}}{2m} - \left(\frac{\sum_{tot} + k_i}{2m} \right)^2 \right] - \left[\frac{\sum_{in}}{2m} - \left(\frac{\sum_{tot}}{2m} \right)^2 \right]$$

where $\sum_{in}$ is the sum of weighted links inside the community, $\sum_{tot}$ is the total number of weighted connections inside the community, k_i is the total number of weighted links related to the community hashtags, and i, $k_{i,in}$ is the total weighted linkages from an individual to the community hashtags, and m is the normalization factor, calculated as the total weighted links over the entire graph (Blondel et al., 2008).

3.3.3. Visual analysis

Techniques for network visualization, such as force-directed layouts, can emphasize various facets of a network, including the density of connections or topic polarization. This phase aimed to discern the polarity of the identified topics. Utilizing the ForceAtlas2 layout technique, a two-dimensional graph was fabricated for visual analysis. An enhanced variant of the ForceAtlas algorithm was deployed, dubbed ForceAtlas2, which concentrates on voluminous networks. This approach harnesses visual representations of smaller samples to pinpoint intercommunity connections within network communities (Jacomy et al., 2014). Visual analysis was executed using the Graphext software (Graphext, 2023).

3.4. Knowledge representation

Knowledge representation is a process that leverages visualization tools to elucidate the discoveries of data mining activities. It underscores the synthesis of individual values and outcomes from the data evaluation stage. The objective of this phase is to bring to the fore pivotal findings from prior analyses.

4. Results and discussion

Based on the collected data, the frequency analysis was conducted to examine the frequency of the hashtags concerning hashtag #burnout. As presented in the Table 3, the 66 hashtags were identified and analyzed.

The Table 3 illustrates the distribution of the hashtags, highlighting their frequencies. The most prominent hashtag is #stress, which occurs 16,889 times—followed by #mentalhealth with 13,306 occurrences, #selfcare with 5,864 occurrences, and #wellbeing with 5,345 occurrences, respectively. In the subsequent analysis, these four most frequent hashtags, along with #depression in the 7th position, are classified under individual factors. The hashtag #healthcare appears in the 5th place with 5,131 occurrences, and due to its general nature, it is categorized as an environmental factor. Additionally, #covid19 ranks 9th, and #health ranks 13th, falling under environmental factors. Among the hashtags classified under organizational factors, the most prominent ones are #leadership in 6th place with 4,782 occurrences, #worklifebalance in 11th place with 3,314 occurrences, #hr. in 12th place with 3,223 occurrences, #work in 14th place, and #productivity in 15th place, both with 2,596 occurrences. Upon comparing the occurrence counts, it becomes evident that the hashtags related to individual factors, such as #stress, #mentalhealth, #selfcare, #wellbeing, and #depression, dominate the communication. The hashtags related to environmental factors, including #healthcare, #covid19, and #health, rank second in frequency, likely influenced by the ongoing COVID-19 pandemic. The third most frequent category of the hashtags pertains to work and working life, encompassing #leadership, #hr., #work, #wfh, and #stressmanagement.

A meticulous examination of the Twitter hashtags has determined that the hashtags related to burnout can be classified into three core groups: *individual*, *organizational*, and *environmental factors* (see Tables 4–6). This systematic categorization facilitates a holistic comprehension of the diverse elements that contribute to the occurrence of burnout and thus reflects people's real-world communication about burnout syndrome.

The *individual factors* group related to burnout contains the 23 hashtags (see Table 4), which can be divided into five groups (mental health, work-life balance, coping skills, productivity, and personality traits). The most posted hashtags regarding individual burnout factors were #stress (16,899 occurrences) and #mentalhealth (13,306 occurrences). Wu and Hong (2022), in their analysis, suggested that 277 out of all 14,015 comments contained the following selected mental health-related words: depression, depressed, anxiety, anxious, stress, and disorder(s). This analysis was confirmed by Golonka et al. (2019). Thus, individual factors of burnout are anxiety, neuroticism, and depression. According to the analysis, #depression was in the 7th place (4,441 occurrences) and #depressionen in the 27th place (1,734 occurrences) and #anxiety in the 10th position (3,335 occurrences). Workplace conditions cause job stress and negatively impact personal performance and overall physical and mental health (Parker and DeCotiis, 1983). Research by Wu et al. (2021) showed that perceived life stress and job stress are predictors of occupational burnout and play a significant role. If ignored, stress can lead to burnout (Thomas et al., 2019). Research also supports the empirical overlap of emotional exhaustion and depression (Golonka et al., 2019). According to Maslach et al. (2001), burnout is a syndrome described as a state of exhaustion. Exhaustion is connected not only to burnout but also to fatigue. According to Sikaras et al. (2021), both fatigue and burnout can lead to a feeling of mental and physical exhaustion. Overall, according to Weston et al. (2019), a pilot evaluation of the mental health awareness for managers training suggests that courses on mental health awareness can positively impact attendees' awareness of

TABLE 1 The frequency of the hashtags related to burnout syndrome on the Twitter.

Position	Hashtag	Total count
1	#stress	16,889
2	#mentalhealth	13,306
3	#selfcare	5,864
4	#wellbeing	5,345
5	#healthcare	5,131
6	#leadership	4,782
7	#depression	4,441
8	#wellness	4,328
9	#covid19	3,818
10	#anxiety	3,335
11	#worklifebalance	3,314
12	#hr	3,223
13	#health	3,015
14	#work	2,881
15	#productivity	2,596
16	#mindfulness	2,242
17	#resilience	2,198
18	#podcast	2,175
19	#wfh	1,929
20	#physician	1,885
21	#energy	1,872
22	#medtwitter	1,868
23	#boundaries	1,860
24	#healing	1,802
25	#pandemic	1,772
26	#stressmanagement	1,747
27	#depressionen	1,734
28	#recovery	1,694
29	#breakfastleadership	1,615
30	#business	1,587
31	#workplace	1,584
32	#remotework	1,479
33	#millennials	1,465
34	#management	1,461
35	#naturalhealing	1,408
36	#career	1,365
37	#mentalhealthmatters	1,301
38	#motivation	1,268
39	#travail	1,246
40	#physicians	1,240
41	#coaching	1,219
42	#mentalhealthawareness	1,205
43	#medicine	1,195
44	#chi	1,178

(Continued)

TABLE 1 (Continued)

Position	Hashtag	Total count
45	#ai	1,136
46	#meded	1,128
47	#nurses	1,102
48	#burnoutprevention	1,085
49	#fatigue	1,077
50	#bĂĽcher	1,071
51	#geschenk	1,057
52	#talento	1,050
53	#physicianburnout	1,046
54	#reclutamiento	1,043
55	#balance	1,015
56	#felicidad	1,014
57	#vida	1,012
58	#competitividad	1,000
59	#marcapersonal	993
60	#innovaciĂłn	971
61	#covid	939
62	#entrepreneur	931
63	#workfromhome	914
64	#qvt	910
65	#employees	867
66	#caregiver	854
67	#futureofwork	827
68	#doctors	814
69	#ehr	814
70	#success	799
71	#leaders	769
72	#salud	768
73	#mindset	753
74	#santĂ©	752
75	#stressrelief	732
76	#exhaustion	697
77	#life	695
78	#culture	691
79	#employeewellbeing	690
80	#selflove	490

Source: Own elaboration based on collected data from the Twitter (2023).

and confidence in dealing with mental health issues in the workplace. However, the #mentalhealthawareness was in the 42nd position (1,205 occurrences), strongly connected to burnout prevention.

Based on a review of research and an empirical study according to Sikaras et al. (2021), the link between anxiety and burnout, particularly the dimension of emotional exhaustion, has been confirmed. According to Golonka et al. (2019), among individual characteristics, depression is revealed to be the most important variable. In addition, their research showed that exhaustion is explained mainly by individual factors such as neuroticism and depression (Golonka et al., 2019). However, #exhaustion was posted very rarely (697 occurrences).

The #selfcare is among the most mentioned hashtags (3rd position, 5,864 occurrences) regarding individual burnout factors. A few recently carried out studies highlighted the relationship between burnout and self-care. One study is focused on doctors breaching the boundary between doctors' personal and professional life is potentially a risk for burnout (Morris et al., 2023). Another research for nursing professionals demonstrated that an informal attempt at self-care, like the work processes associated with personal experiences, edifies informal strategies (Sonnentag, 2015). So, it is essential, therefore, the instrumentalization for self-care (Camargo et al., 2021). The #selflove (80th position, 490 occurrences) is not much associated with burnout in scientific articles. The topic of self-love in leadership was addressed by Maharaj and April (2017), who suggest that self-love is at the core of authenticity, servant leadership, empathy, caring for employees, and the ability to listen. Self-love is a rare but vital phenomenon that requires more scientifical understanding.

Another most posted was #wellbeing (5,345 occurrences). The research on well-being and burnout among healthcare professionals dealt with burnout measures to assess well-being (Eckleberry-Hunt et al., 2018). The term well-being is associated with the other hashtags #worklifebalance (3,314 occurrences), #wellness (4,328 occurrences), #energy (1,872 occurrences) and #balance (1,115 occurrences). According to a study by Neumann et al. (2018) focused on oncology nurses, work-life balance is associated with burnout. Thus, one-third of the oncology nurses feel that their work schedule does not provide enough time for personal or family life (Neumann et al., 2018). Keeping a healthy balance between the time and energy one devotes to a career and life outside of work is crucial to preventing burnout (Allen, 2019). So, burnout is considered an occupational disease expressed by loss of mental and physical energy due to prolonged and unsuccessful coping with stressors at work (Grossman et al., 2019).

On the other hand, wellness was revealed as a mitigating factor for burnout. According to Brasfield et al. (2019), wellness may relieve professional stress. Brasfield et al.'s (2019) research results indicate significant relationships between burnout and wellness indicators.

In 16th place was the hashtag #mindfulness (2,242 occurrences). The systematic review focused on healthcare professionals identified that mindfulness-based interventions reduced stress and burnout and increased self-compassion and general health (Sarazine et al., 2021). Other coping skills, #mindset (73rd position) and #stress relief (75th position) were placed in the last positions. However, Zarrinabadi et al.'s (2023) study investigated whether teachers' mindsets about stability or malleability of teaching ability (fixed and growth mindsets) and self-efficacy predicted their burnout and professional identity beliefs. Work-related stress is a significant occupational health problem associated with adverse physical and mental health effects. Physical stress relief methods like yoga and massage therapy may reduce occupational stress (Zhang et al., 2021). Additionally, meditation and mindfulness have been used in many cultures as stress relief (Anderson et al., 1999).

Rapp et al. (2021) concluded that the contextual shock of the COVID-19 pandemic resulted in an increased incidence of boundary violations-undesired disruptions between work and other important life domains such as personal and family life. These boundary

TABLE 2 Removed hashtags.

Position	Hashtag	Total count
44	#chi	1,178
50	#bÄĽcher	1,071
51	#geschenk	1,057
52	#talento	1,050
54	#reclutamiento	1,043
56	#felicidad	1,014
57	#vida	1,012
58	#competitividad	1,000
59	#marcapersonal	993
60	#innovaciÄłn	971
64	#qvt	910
69	#ehr	814
72	#salud	768
74	#santÄ©	752

Source: Own elaboration (2023).

violations, which we classify as physical, temporal, or knowledge-based, frequently correspond to greater burnout reports manifested by exhaustion, detachment, and inefficacy. According to research by Graña et al. (2021), Pearson correlations showed that #motivation (38th position among the hashtags) is negatively related to burnout and positively to engagement, while burnout and engagement are inversely related.

In addition, the hashtag success is related to burnout in the context of productivity. Grebski and Mazur (2022) state that undetected and untreated burnout leads to decreased employee productivity. So, preventing employee burnout leads to increased productivity and economic success for the company. The hashtag #resilience as a personal trait was in the 17th position. It was the only one belonging to the group of individual factors. The connection between burnout and resilience was confirmed. According to the research of Győrffy (2019), results have shown that internal resources, coping strategies and resilience play a crucial role in burnout and its decrease.

The *organizational factors* group related to burnout contains the 21 hashtags (see Table 5). After further investigation, this group can be divided into four subgroups: work-related factors, telecommuting, personal development and well-being, and generational focus.

Work-related factors encompass the hashtags such as #work, #workplace, #business, #travail, #management, #leadership, #breakfastleadership, #leaders, #hr., #employees, #career, #entrepreneur, and #futureofwork. These hashtags represent discussions surrounding work-related stressors, job demands, leadership styles, career development, and the overall work environment. Numerous studies have highlighted the significance of work-related factors, such as high job demands, low control, and lack of support, in contributing to burnout (Demerouti et al., 2001; Maslach et al., 2001; Schaufeli et al., 2009). Effective management and leadership are crucial in reducing burnout. In this context, the hashtag #leadership ranked sixth with a total of 4,782 occurrences, followed by the related hashtags #breakfastleadership (1,615 occurrences) and #leaders (769 occurrences). The hashtag #management is in 34th place with 1,461 occurrences. According to Schaufeli and Bakker (2004), job resources provided by managers and leaders, such as support, feedback, and growth opportunities, play a vital role in preventing burnout. Bakker and Demerouti (2017) emphasize the importance of managing job demands to avoid excessive stress and exhaustion. HRM practices also play a significant role in preventing burnout. The hashtag #hr. is in 12th place with 3,223 occurrences. Research by Demerouti et al. (2001) suggests that HR practices that focus on meeting employees' basic psychological needs, such as autonomy, competence, and relatedness, can reduce burnout. Van den Broeck et al. (2008) further emphasize the importance of HR practices that satisfy these psychological needs to enhance employee well-being and engagement while mitigating burnout. Career development is another essential aspect. The hashtag #career is in 36th place with 1,365 occurrences. Employees who actively shape their work tasks and career paths to align with their strengths and interests experience lower levels of burnout (Tims et al., 2013). It suggests that organizations should provide opportunities for employees to engage in job crafting and support their career development to prevent burnout and enhance job satisfaction. Burnout risks are also relevant in the context of the future of work (#futureofwork with 827 occurrences). Darouei and Pluut (2021) discuss the challenges of balancing the demands of virtual work and family responsibilities. The study highlights the importance of organizations implementing policies and practices that support work-life balance to prevent burnout among remote employees (Darouei and Pluut, 2021). Demerouti et al. (2012) emphasize the need to consider the work-family interface from a life and career perspective, suggesting that organizations should provide support and flexibility to address employees' demands and challenges in managing work and family responsibilities.

Telecommuting subgroup is represented by the hashtags like #wfh, #remotework, and #workfromhome. The hashtags #wfh ranked sixth with 1,929 occurrences, #remotework 32nd with 1,479 occurrences and #workfromhome 63rd with 914 occurrences. The COVID-19 pandemic has significantly increased the prevalence of remote work, and discussions around the challenges and potential burnout risks associated with telecommuting have emerged. Research has shown that telecommuting can lead to blurred boundaries between work and personal life, increased workload, and reduced social support, which may contribute to burnout (Derks et al., 2016; Darouei and Pluut, 2021). Remote work involves working outside the traditional office, typically from home or other remote locations. While remote work offers flexibility and autonomy, it also presents challenges that can impact employee well-being and increase the risk of burnout. Derks et al. (2016) found that remote employees often face difficulties maintaining work-life balance due to blurring boundaries between work and personal life. Furthermore, the increased workload associated with remote work can contribute to burnout. Darouei and Pluut (2021) suggest that remote employees may experience higher job demands, such as increased workload and a lack of clear boundaries between work and personal life, leading to heightened stress and exhaustion. Additionally, Derks et al. (2016) found that remote employees reported lower levels of social support from colleagues than those working in traditional office settings. The absence of informal interactions and reduced opportunities for face-to-face communication may limit the availability of social support networks, which can act as protective factors against burnout.

TABLE 3 The frequency of the used hashtags related to burnout syndrome on the Twitter.

Position	Hashtag	Total count	Position	Hashtag	Total count
1	#stress	16,889	34	#management	1,461
2	#mentalhealth	13,306	35	#naturalhealing	1,408
3	#selfcare	5,864	36	#career	1,365
4	#wellbeing	5,345	37	#mentalhealthmatters	1,301
5	#healthcare	5,131	38	#motivation	1,268
6	#leadership	4,782	39	#travail	1,246
7	#depression	4,441	40	#physicians	1,240
8	#wellness	4,328	41	#coaching	1,219
9	#covid19	3,818	42	#mentalhealthawareness	1,205
10	#anxiety	3,335	43	#medicine	1,195
11	#worklifebalance	3,314	45	#ai	1,136
12	#hr	3,223	46	#meded	1,128
13	#health	3,015	47	#nurses	1,102
14	#work	2,881	48	#burnoutprevention	1,085
15	#productivity	2,596	49	#fatigue	1,077
16	#mindfulness	2,242	53	#physicianburnout	1,046
17	#resilience	2,198	55	#balance	1,015
18	#podcast	2,175	61	#covid	939
19	#wfh	1,929	62	#entrepreneur	931
20	#physician	1,885	63	#workfromhome	914
21	#energy	1,872	65	#employees	867
22	#medtwitter	1,868	66	#caregiver	854
23	#boundaries	1,860	67	#futureofwork	827
24	#healing	1,802	68	#doctors	814
25	#pandemic	1,772	70	#success	799
26	#stressmanagement	1,747	71	#leaders	769
27	#depressionen	1,734	73	#mindset	753
28	#recovery	1,694	75	#stressrelief	732
29	#breakfastleadership	1,615	76	#exhaustion	697
30	#business	1,587	77	#life	695
31	#workplace	1,584	78	#culture	691
32	#remotework	1,479	79	#employeewellbeing	690
33	#millennials	1,465	80	#selflove	490

Source: Own elaboration based on collected data from the Twitter (2023).

Personal development and well-being are crucial aspects of organizational factors related to burnout. The hashtags such as #burnoutprevention, #employeewellbeing, #stressmanagement, and #coaching reflect the focus on organizational initiatives to prevent burnout and promote well-being. Proactive interventions such as stress management programs, employee support systems, and coaching effectively reduce burnout and enhance well-being (Fothergill et al., 2004; IsHak et al., 2009; Siu et al., 2014; Grawitch et al., 2015). The hashtag #stressmanagement is in 26th place with 1,747 occurrences. Stress management, for example, provides employees with techniques and skills to effectively manage and reduce stress levels, thereby mitigating the risk of burnout. The hashtag #burnoutprevention is in 48th place with 1,085 occurrences. Burnout prevention strategies aim to equip individuals with the tools and resources necessary to manage and cope with the demands of their work. Fothergill et al. (2004) highlight the importance of such interventions in enhancing well-being and preventing burnout. Employee well-being initiatives, encompassing various aspects such as physical health, mental well-being, and work-life balance, also play a critical role in burnout prevention. Implementing employee support systems that provide resources, guidance, and assistance to employees in times of stress or difficulty can contribute to a healthier work environment and reduce the likelihood of burnout. Grawitch et al. (2015) emphasize the positive impact of supportive organizational systems in fostering employee well-being and preventing burnout. Another approach to addressing burnout and promoting personal

TABLE 4 The hashtags shared alongside the hashtag #burnout categorized as individual factors.

Individual factors		
Position	Hashtag	Total count
1	#stress	16,889
2	#mentalhealth	13,306
3	#selfcare	5,864
4	#wellbeing	5,345
7	#depression	4,441
8	#wellness	4,328
10	#anxiety	3,335
11	#worklifebalance	3,314
15	#productivity	2,596
16	#mindfulness	2,242
17	#resilience	2,198
21	#energy	1,872
23	#boundaries	1,860
27	#depressionen	1,734
38	#motivation	1,268
42	#mentalhealthawareness	1,205
49	#fatigue	1,077
55	#balance	1,015
70	#success	799
73	#mindset	753
75	#stressrelief	732
76	#exhaustion	697
80	#selflove	490

Source: Own elaboration based on collected data from the Twitter (2023).

TABLE 5 The hashtags shared alongside the hashtag #burnout categorized as organizational factors.

Organizational factors		
Position	Hashtag	Total count
6	#leadership	4,782
12	#hr	3,223
14	#work	2,881
19	#wfh	1,929
26	#stressmanagement	1,747
29	#breakfastleadership	1,615
30	#business	1,587
31	#workplace	1,584
32	#remotework	1,479
33	#millennials	1,465
34	#management	1,461
36	#career	1,365
39	#travail	1,246
41	#coaching	1,219
48	#burnoutprevention	1,085
62	#entrepreneur	931
63	#workfromhome	914
65	#employees	867
67	#futureofwork	827
71	#leaders	769
79	#employeewellbeing	690

Source: Own elaboration based on collected data from the Twitter (2023).

development is coaching. The hashtag #coaching is in 41st place with 1,219 occurrences. It focuses on supporting individuals in identifying and achieving their goals, enhancing their strengths, and developing strategies to manage challenges and stressors. Such interventions have been shown to reduce burnout and enhance well-being by improving self-awareness, resilience, and adaptive coping mechanisms (Grant et al., 2009).

Lastly, the subgroup of generational focus is represented by the hashtag #millennials, ranked in 33rd place with 1,465 occurrences. Discussions surrounding millennials and burnout shed light on the unique challenges faced by this generation in the workplace. Factors such as job insecurity, high expectations, and the pressure to achieve a work-life balance contribute to higher levels of burnout among millennials (Schonfeld and Bianchi, 2016). Millennials, born between the early 1980s and mid-1990s (McCrindle, 2011), have been found to experience higher levels of burnout compared to other generational cohorts. Schonfeld and Bianchi (2016) suggest that millennials face significant challenges in the modern work environment, including economic uncertainty, demanding workloads, and a strong desire for work-life balance. A study by Twenge et al. (2010) found that millennials reported higher levels of job insecurity than previous generations, which can negatively impact their well-being and increase the risk of burnout. Additionally, the high expectations placed on millennials, both internally and externally, can contribute to burnout. These expectations, combined with intense competition and the pressure to excel, can result in heightened stress levels and burnout (Twenge et al., 2012). Understanding the generational dynamics and their implications is crucial for effectively addressing burnout among different generations of employees. Organizations should consider implementing strategies that support work-life balance, provide opportunities for growth and development, and offer meaningful work experiences to help mitigate the risk of burnout.

In conclusion, work-related, telecommuting, personal development and well-being, and generational focus factors significantly impact employee burnout. While these groups are initially derived from the Twitter hashtags, it is worth noting that these categories align with research findings, substantiating their significance concerning burnout. Effective management and leadership, supportive HR practices, attention to career development, and adapting to the future of work are essential in preventing burnout and promoting employee well-being. Organizations should be mindful of telecommuting challenges and take proactive measures to support remote employees in managing their workloads, establishing clear boundaries, and fostering social connections to mitigate the risk of burnout. Further, personal development and well-being initiatives are integral to organizational efforts to prevent employee burnout. Also, addressing diverse generational differences and needs by organizations

TABLE 6 The hashtags shared alongside the hashtag #burnout categorized as environmental factors.

Environmental factors		
Position	Hashtag	Total count
5	#healthcare	5,131
9	#covid19	3,818
13	#health	3,015
18	#podcast	2,175
20	#physician	1,885
22	#medtwitter	1,868
24	#healing	1,802
25	#pandemic	1,772
28	#recovery	1,694
35	#naturalhealing	1,408
37	#mentalhealthmatters	1,301
40	#physicians	1,240
43	#medicine	1,195
45	#ai	1,136
46	#meded	1,128
47	#nurses	1,102
53	#physicianburnout	1,046
61	#covid	939
66	#caregiver	854
68	#doctors	814
77	#life	695
78	#culture	691

Source: Own elaboration based on collected data from the Twitter (2023).

can create a supportive and engaging work environment. By understanding and addressing identified organizational factors, organizations can create healthier work environments and mitigate the risks of burnout.

The *Environmental factors* encompass many aspects associated with burnout syndrome (see Table 6 with the 22 hashtags). Notably, a significant representation of the hashtags related to the COVID-19 pandemic is observed, indicating its negative impact on the prevalence of burnout syndrome in various professions (Torres et al., 2023). The hashtag #covid19 ranks 9th with a frequency of 3,818 occurrences, making it one of the prominent hashtags within the environmental factors category. Additionally, #pandemic appears in 25th place with a frequency of 1,772, and #covid ranks 61st with 939 occurrences. The COVID-19 pandemic has brought about numerous changes in healthcare systems, resulting in reduced accessibility and increased pressures on healthcare professionals who face the challenges of an overwhelmed system (Shapiro et al., 2019). Research has also demonstrated a rise in burnout syndrome among college students during the COVID-19 pandemic as they grappled with prolonged crises and new threats (Tomaszek and Muchacka-Cymerman, 2022). The hashtag #life appears in the 77th position with a frequency of 691. At the same time, #culture emerges in the 78th place with 995 occurrences, indicating that the Twitter users recognize the significance of health and quality of life (Jois et al., 2018) and address burnout syndrome in the context of natural healing and medicine (Jones et al., 2007).

Further, the impact of the COVID-19 pandemic has heightened concerns for individuals' health and life. The hashtag #healthcare ranks 5th with 5,131 occurrences, while #mentalhealthcare appears in the 42nd position with 1,205 occurrences, emphasizing the association between healthcare, mental health, and burnout syndrome (West et al., 2022). Burnout syndrome has been examined across various groups of employees in studies (Tzu et al., 2017), and its communication is linked to the hashtags #healing (ranked 24th) and #naturalhealing (ranked 35th), reflecting both Western and Eastern medicine perspectives (Tzu et al., 2017). Burnout syndrome has been described as impacting society's personal, organizational, social, and economic levels (Jois et al., 2018). Several posts include the hashtags related to healthcare professions and medicine, such as #doctors (ranked 68th) with 814 occurrences, #nurses (ranked 47th) with 68 occurrences, #psychiatrist (ranked 20th) with 1,885 occurrences, #medicine (ranked 43rd) with 1,195 occurrences, #meded (ranked 46th) with 1,128 occurrences, and #recovery (ranked 28th) with 1,694 occurrences. As health and social professions face the challenges of increased patient demands, the rise in burnout syndrome becomes evident (Klein et al., 2020).

The prevalence of the hashtags in posts related to burnout syndrome indicates a connection between the health and work domains, highlighting the impact of personal and work-related stress and its management (Letson et al., 2020). De Diego-Cordero et al. (2022) state that nurses and physicians are the most at-risk groups. Medical facility management faces the challenge of addressing burnout syndrome in these high-risk employees (Chaput et al., 2015; Bernez et al., 2018). Setting up regular meetings and facilitating discussions with other professionals has been identified as one strategy to combat burnout syndrome (Chaput et al., 2015; Rosada et al., 2015). Collective sharing of group projects has also emerged to combat burnout syndrome (Torres et al., 2023). Burnout syndrome has also increased in other professional groups, such as teachers (Anama-Green, 2022), childcare center employees with multidisciplinary training and social employees (Letson et al., 2020). In their study, Suyi et al. (2017) demonstrated a link between burnout syndrome, healthcare, and staff turnover.

The prevalence of the hashtags associated with burnout syndrome suggests that the Twitter users are aware of the influence of environmental factors on their work and personal lives. Company management should acknowledge the need to address the manifestations of burnout syndrome, as it impacts the quality of work life and employee well-being, which are essential for the sustainability of organizations (Golonka et al., 2019).

The topic analysis enables a better understanding of the overall communication dynamics by identifying the connections between the hashtags. The Table 7 presents the results of the topic analysis, identifying the topics (cluster names) within the Twitter communication related to burnout syndrome from January 1st, 2019, to July 31st, 2022. A total of seven main topics were identified: (1) Workplace, (2) Healthcare, (3) Communication, (4) Stress and Therapy, (5) Rhythms of Rest, (6) Symptoms, and (7) Leadership. These topics are discussed in detail below.

The largest identified topic relates to the *Workplace*, accounting for 15% of the total share and occurring 28,470 times. The Workplace topic encompasses aspects of the organization, including employee,

TABLE 7 Results of the topic analysis.

Cluster name	Key terms	Selection count	Percentage
(1) Workplace	employee, work, workplace, job, HR, employer, company, worklifebalance, career	28,470	15%
(2) Healthcare	physician, healthcare, doctor, nurse, patient, care, medicine, health, hospital, health care, clinical	22,177	12%
(3) Communication	podcast, episode, book, youtube, listen, video, join, talk, share, live, free	20,545	11%
(4) Stress and Therapy	depression, stress, anxiety, psychotherapy, mentalhealth, psychiatrie, mindfulness, resilience, meditation, howfightdepression, notjustmood	17,239	9%
(5) Resting	day, time, sleep, week, rest, holiday, break, weekend, tired, feel	16,089	8%
(6) Symptoms	sign, burn, symptom, feel, avoid, prevent, exhaustion, signs of burnout, experience, feeling, stress	15,666	8%
(7) Leadership	leadership, team, leader, manager, coach, CEO, HR, management, coaching, executive, lead	9,538	5%

Source: Own elaboration based on collected data from the Twitter (2023).

work, workplace, job, HR, employer, company, and work-life balance. The cluster focused on workplace issues mainly consists of terms related to the organizational factors of burnout, such as employee, work, workplace, HR, and career. However, the term employer is not included in any burnout factors, although there is a connection to the term entrepreneur. According to the Cambridge Dictionary (2023b), an entrepreneur is "*a person who attempts to make a profit by starting a company or by operating alone in the business world,*" while an employer is "*a person, company, or organization that employs people*" (Cambridge Dictionary, 2023a). Additionally, the term work-life balance was categorized under individual factors of burnout. However, according to Sirgy and Lee (2018), the work-life balance model is based on personal and organizational predictors. Furthermore, one of the results of their model are work-related outcomes, which are connected to performance management and HRM topics.

The second most identified topic is *Healthcare*, occurring 22,177 times and accounting for an overall share of 12%. The Healthcare topic includes aspects related to physicians, healthcare, doctor, nurse, patient, care, medicine, health, hospital, healthcare, and clinical. It mainly focuses on environmental factors of burnout (physician, doctor, nurse, healthcare, medicine). However, the term patient is not included in any specific factors. It is related to the type of burnout, specifically client-related and professional burnout. The concept of a client varies depending on the context of client-related burnout and the level of burnout. According to Chin et al. (2018), the term client refers to people who receive services from individuals providing the service. Therefore, many studies explore healthcare providers, the quality of healthcare, and the prevention of burnout (Salyers et al., 2017). However, one of the main factors influencing the topic of burnout was the COVID-19 pandemic, during which people became increasingly concerned about their healthcare. As a result, burnout research was primarily associated with healthcare providers.

Communication is the third identified topic, with 20,547 occurrences and a total share of 11%. This topic encompasses aspects related to different means or forms of communication, such as podcasts, episodes, books, YouTube, listening, videos, joining, talking, sharing, live events, and free content. So, there are mainly mentioned new media focused on interaction. Thus, Charoensukmongkol's (2016) study suggests that using social media during work tends to increase burnout in employees with a low mindfulness level. Still, it lowers burnout in employees with a high mindfulness level. In addition, social media such as the Facebook, Twitter, and Instagram have played key roles in online communications in recent years. However, Han (2018) points out social media burnout concerning burnout syndrome, where he finds that ambivalence, emotional exhaustion, and depersonalization can significantly negatively influence a user's social media continuance.

The fourth topic, *Stress and Therapy*, encompasses stress-related aspects of burnout syndrome and terms related to individual burnout factors. It holds an overall share of 9% with a total frequency of the 17,239 hashtags. Notable aspects highlight the link between burnout syndrome and stress and mental state, including terms such as depression, stress, anxiety, psychotherapy, mental health, psychiatry, mindfulness, resilience, and meditation. Terms howfightdepression and notjustmood are not included in any classification. The results show a need to prevent burnout focused on employees' self-initiative actions (Otto et al., 2021).

The fifth topic is *Resting*, with a total share of 8% and a frequency of the 16,089 hashtags. It encompasses aspects of life's daily rhythm and time component, including concepts like day, time, sleep, week, rest, holiday, break, and weekend. These terms are more related to personal factors of burnout. The discrepancy might be caused by employees' working time, flexibility, and satisfaction, as stated by Lee and Chang (2022). Thus, in the context of burnout syndrome review focused on clinical physicians was carried out. The results showed that flexible arrangements concerning working time might reduce burnout risk, and improve overall job satisfaction, as exhibited by physicians working within hospital settings (Helmig et al., 2010).

The sixth topic, *Symptoms*, comprises the 15,666 hashtags, accounting for a total share of 8%. It encompasses items such as signs, burn, symptom, feel, avoid, prevent, exhaustion, signs of burnout, experience, feeling, and stress. These terms indicate various aspects associated with burnout syndrome. It is a mixture of individual factors of burnout and burnout prevention elements. Burnout symptoms, defined as consequences of chronic work stress, are an increasing problem (Aust et al., 2022).

The final topic is *Leadership*, with a total of the 9,538 hashtags, accounting for a share of 5%. It encompasses terms such as leadership, team, leader, manager, coach, CEO, HR, management, coaching, executive, and lead. It deals with HR, the management board and the team. Although this topic is the last, the importance of leadership was confirmed by Tian and Guo (2022), who explored the underlying mechanisms and boundary conditions of the relationship between transformational leadership and teacher burnout.

A visual analysis (see the Figure 3) has identified that the density of connections is evident for the themes of Resting and Communication and Workplace and Leadership. However, the theme of Resting appears to connect Communication and the Workplace

with Leadership. The close link between the Workplace and Leadership themes stems from their organizational nature. Thus, the theme of Resting as a form of prevention of burnout syndrome is the focus of the education or awareness disseminated through multimedia communication (podcasts, videos, book, youtube, etc.). Topic Healthcare appears relatively isolated from other topics, probably due to its focus on the medical field. Between the Healthcare and Communication poles is the Stress and Therapy theme, intertwined with Symptoms through Resting.

5. Conclusion

The study results reveal that individuals discussing burnout syndrome on the Twitter perceive its symptoms as belonging to either the individual spectrum or the broader environmental factors of their lives. These findings align with the theories (Hallsten et al., 2011), establishing a clear connection between burnout syndrome and an individual's work life. Consequently, organizations must address burnout prevention within their HRM practices, as they can take the initial steps to mitigate it. HRM can specifically address the employee's bio-socio-psycho components, including employee care, training, planning, and evaluation. Furthermore, this employee care should be integrated into the organization's culture, particularly regarding workplace relationships, negotiations, communication, and conflict resolution. The paper also demonstrates that discussions on burnout syndrome on the Twitter primarily revolve around stress, mental health, and self-care. It is worth mentioning the relevance of well-being and healthcare in this context. Although these topics are associated with individual factors, HRM possesses the capacity to influence these areas. The Twitter users also perceive a connection between burnout syndrome, organizational leadership, and the general environment, with the COVID-19 pandemic exerting a notable influence. Consequently, the Twitter users recognize various aspects that impact their personal lives, with a foundation in their working lives. These findings suggest that HRM should prioritize contemporary issues such as work-life balance and employee care. As demonstrated by the results, communication about burnout syndrome encompasses all its factors and should be considered from this perspective across different HRM domains.

The staff training aspect should prioritize the prevention of burnout syndrome, mental hygiene, stress management, and time management. The findings indicate that these topics are directly linked to the hashtags associated with burnout syndrome. Regarding workforce planning, it is crucial to adopt an HRM perspective that considers all social roles of employees to ensure a healthy work-life balance. The hashtags such as #work, #career, #leadership, #productivity, and #motivation demonstrate the connection between perceived burnout symptoms and their manifestation in the work environment. Employee deployment should be carefully considered when planning the workforce, including horizontal or vertical movement, to align with their

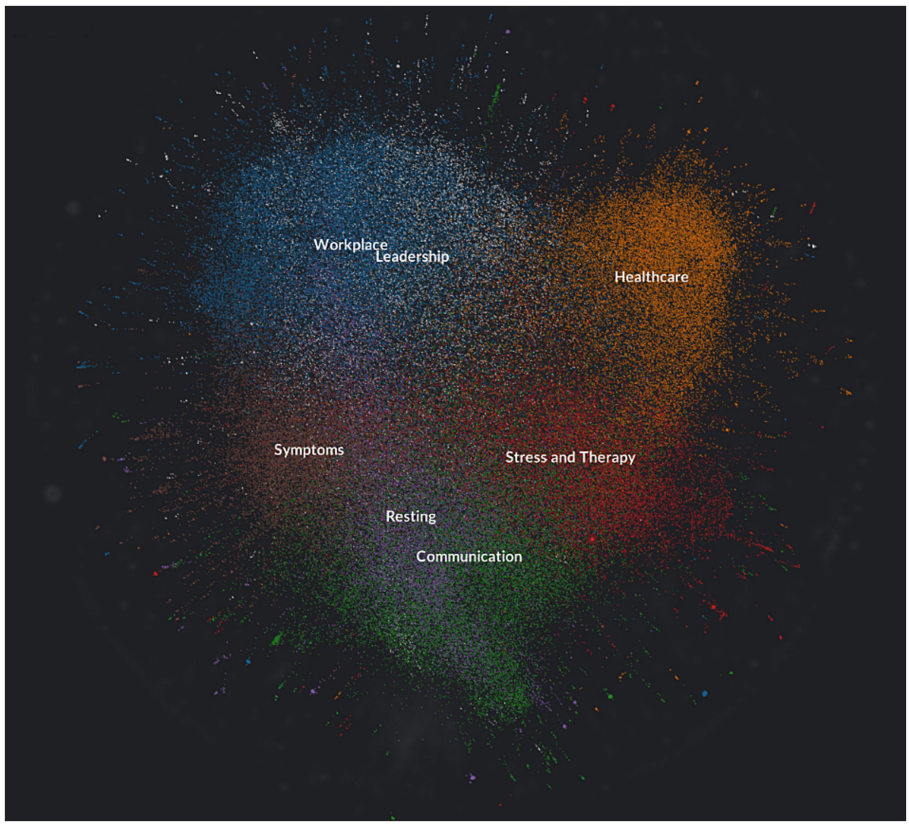

FIGURE 3
Visual analysis of theme connections and focus areas, Source: Own elaboration based on collected data from the Twitter using Graphext software (Graphext, 2023).

work-life balance and motivation. Workforce development plans can serve as a motivational tool, but they may also create pressure to perform, potentially contributing to burnout syndrome, even if they are met. Therefore, these plans must align with the organization's strategic objectives and the individual employees' preferences. Regular self-development, which may involve stress management training, should also be prioritized.

The impact of burnout not only affects employee and organizational performance, but studies also highlight the factors contributing to low individual and organizational performance (Chowdhury, 2018; Firdaus et al., 2023; Wulantika et al., 2023). Specifically, individual factors such as #stress, #productivity, #resilience, #success, and #fatigue are discussed concerning the employee. On the employer's side, organizational factors such as #hr., #work, #workplace, and #remotework are emphasized. Performance appraisal plays a crucial role in performance management. The outcomes of a formal performance appraisal system can be utilized in other areas of HRM within the Michigan model framework (Fombrun et al., 1984), such as learning and development and rewarding. Furthermore, as a core performance appraisal method, the performance appraisal interview provides valuable feedback to employees and employers.

Our study also highlights workplace relationships' significance in preventing burnout. In addition to performance, the level of teamwork is recognized as a manifestation and impact of burnout. The most frequently mentioned the hashtags related to this topic were those related to organizational factors such as #leadership, #hr., #millenials, and #management. The hashtags like #wellbeing and #worklifebalance were the most cited concerning individual factors. These findings reinforce the importance of establishing an effective HRM system to prevent burnout syndrome, particularly in HRM, performance appraisal, training and development, workforce planning, and employee well-being.

One factor significantly impacting employee burnout is organizational culture, which necessitates special attention from HRM and decision-makers (Ghorbanian et al., 2018). While burnout syndrome is often seen as an individual issue, the responsibility for its management is increasingly shifting from employees to employers. Employee care serves as a reflection of organizational culture, and therefore, proactive efforts to enhance organizational culture and prioritize employee well-being are highly recommended. Creating a work environment that promotes well-being involves various measures such as improving the ergonomics of the workspace, providing benefits that support mental and physical health, offering tailored support for parents or caregivers, facilitating training opportunities, optimizing recruitment processes, implementing effective onboarding and outplacement practices, and fostering company rituals. The significance of organizational culture's influence is exemplified by the findings of the topic analysis, where the most prevalent identified topic is Organization, encompassing key terms such as #employee, #work, #workplace, #job, #HR, #employer, #company, #worklifebalance, and #career.

Theoretical implications of this paper offer a fresh perspective on understanding the communication surrounding burnout syndrome, highlighting the importance of individual, organizational, and environmental factors. This breakdown, encompassing these three factors, holds particular significance within organizational management theory and HRM. Additionally, the study's theoretical contribution lies in its unique approach of utilizing big data analysis from the Twitter to investigate burnout communication, as no prior studies have explored this.

From a practical point of view, the study's findings have implications for strategic management and HRM. At the strategic management level, organization's can incorporate the concept of burnout syndrome into their values and philosophy, focusing on organizational aspects, working hours, and work-life balance. This approach aligns with work-life balance, well-being, and self-care principles, enhancing employee care, workplace relationships, communication, and overall job satisfaction. A satisfied and motivated workforce provides a competitive advantage for employers and helps foster and reinforce the organizational culture, values, and strategic goals. For HRM, the study findings offer practical benefits for managers in various areas. These include workforce planning, the formulation of HRM policies, team building, team leadership, employee evaluation, and motivation. Given the nature of jobs and roles, which often entail significant responsibility and require refined soft skills such as decision-making, adaptability, communication, autonomy, and stress management, managers can apply a management approach to structure job descriptions, optimize staff development plans, streamline job and role descriptions, and manage employees' careers. This approach addresses factors associated with burnout and promotes a healthier work environment.

While this study has provided valuable insights into the communication of burnout syndrome on the Twitter and its implications for HRM, it is vital to acknowledge the limitations that may affect the generalizability and interpretation of the findings. First is the restriction to a specific location of posts, which makes it challenging to generalize the findings to other contexts. Despite this limitation, the study has provided valuable insights based on the perspectives of HRM professionals regarding burnout prevention. Second is the focus on a specific target group. However, the results offer a comprehensive understanding of the factors associated with burnout from HRM and social media perspectives. The findings have implications for burnout prevention and communication on social media, particularly in collaboration with HRM professionals. Third is the timeframe of the data collected. It would be beneficial to compare the results obtained from this study on burnout communication on the Twitter with other studies, such as an omnibus study or a panel study, to determine whether the hashtags and topics related to burnout syndrome change over time. Future studies should investigate burnout syndrome in social media communication and its relationship with HRM, organizational culture, work-life balance, and well-being. Further, future studies should address performance appraisal and outcomes to prevent burnout syndrome. By addressing these areas, further insights can be gained to advance our understanding of burnout and its management in contemporary contexts.

Data availability statement

The datasets analyzed for this study can be found at the Zenodo: https://zenodo.org/record/8014694. In consideration of Twitter's terms and conditions, along with ethical and legal considerations, the dataset includes Tweet IDs to ensure the reproducibility of the research.

Author contributions

LK and LP initiated the study and contributed to data curation, formal analysis, visualization, and methodology. GJ, KD, KZ, and KK contributed to the conception, design of the study, and performed the analysis, wrote sections of the manuscript. GJ, KD, and KZ prepared parts of the text, resources, and wrote the first draft of the manuscript. KZ prepared the figures, tables, and translated and finalized the manuscript to the template. KK made conceptualization. GJ, KK, and KZ made supervision. LP funding acquisition. All authors contributed to the manuscript's revision and read and approved the submitted version.

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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/fpsyg.2023.1236491/full#supplementary-material

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Effects of fear of missing out on inhibitory control in social media context: evidence from event-related potentials

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The present study aimed to investigate the impact of fear of missing out (FoMO) on inhibitory control in social media context. The present study used a two-choice oddball task combined with event-related potentials (ERPs) technology to measure inhibitory control. Based on the Fear of Missing Out Scale, participants with varying degrees of FoMO were recruited to complete two studies. A total of 78 participants in Study 1 completed a two-choice oddball task (stimuli "W" or "M"). The results showed that FoMO did not have a significant impact on general inhibitory control at both the behavioral and electrophysiological levels. To further examine the effect of FoMO in social media context. In Study 2, 72 participants completed a modified two-choice oddball task with three types of pictures (high and low social media-related and neutral). The behavioral results revealed that as FoMO scores increased, inhibitory control decreased. ERP analysis revealed that with higher FoMO scores, social media-related pictures elicited larger N2 amplitude and smaller P3 amplitude, but not for neutral pictures. This suggests that FoMO undermines inhibitory control by consuming more cognitive resources in the early conflict detection stage and leading to insufficient cognitive resources in the later stages of the inhibitory process. These findings suggest that FoMO can undermine inhibitory control in the social media context. Considering the indispensable use of social media in the digital age, addressing and understanding the influence of FoMO on inhibitory control could be essential for promoting healthy digital behaviors and cognitive functions.

KEYWORDS

fear of missing out, inhibitory control, event-related potentials, social media, two-choice oddball task

1. Introduction

As social media continues to advance rapidly, it has become the primary platform for interpersonal interaction (1). Recently, researchers have found that using social media may induce fear of missing out (FoMO), as individuals worry about potentially missing rewarding experiences such as interesting things and important notifications (2, 3). Przybylski et al. (3) found that individuals with FoMO tend to be easily distracted by engaging in social media activities, resulting in a lack of attention (e.g., distracted driving and studying). Previous research has demonstrated that distractions can diminish attentional control during ongoing tasks, thereby undermining individuals' inhibitory control (4, 5). Inhibitory control is a critical

cognitive process that involves the ability to restrain from engaging in inappropriate or unnecessary behaviors (6). Issues related to inhibitory control can contribute to problematic social media use and negatively impact one's quality of life (7, 8). While numerous studies have illustrated the impact of FoMO on psychological aspects and social media abuse (2, 9, 10), whether and how FoMO affects inhibitory control remains unclear.

Previous studies have investigated a wealth of evidence suggesting that negative emotions (e.g., anxiety, disgust, and fear) can affect inhibitory control (11–13). For example, Xia et al. (12) found that individuals with high-trait anxiety exhibited poorer accuracy and longer reaction times compared to those with low-trait anxiety. As inhibitory control involves multiple processes, such as conflict detection and response inhibition (14, 15). Event-related potentials (ERPs) with high temporal resolution have been recommended as a method for investigating inhibitory control. Two related ERP components were employed to assess the processes of inhibitory control. The first component is the N2, a negative waveform emerging approximately 200–400 ms after the signal presentation with a frontocentral distribution. The N2 serves as an indicator of the early stages of the inhibitory process (14). The N2 amplitude was interpreted as the cognitive resources consumed by the earlier conflict detection (16, 17). Another component is the P3, a positive waveform arising from 300 to 600 ms after signal onset with a parietal-central distribution. The P3 reflects the late stage of the inhibitory process response and is associated with the actual inhibition of the motor system (18–20). The increase in P3 amplitude indicates that more cognitive resources need to be consumed to invest in the response process (12).

A previous study found that individuals with high-trait anxiety exhibit smaller N2 amplitude and larger P3 amplitude compared to those with low-trait anxiety (12). Furthermore, Wei et al. (16) found that individuals with high test anxiety exhibited a larger N2 amplitude than those with low test anxiety in the performance evaluation threat conditions. This increase in N2 amplitude was associated with heightened top-down attentional control resources in individuals with high test anxiety. Xu et al. (13) found that the P3 amplitude in disgusting contexts was smaller than in fearful contexts, as disgust consumes more attentional resources during the early stages of the inhibitory process. FoMO also presents such a feature. Individuals experiencing FoMO may worry about missing out on rewarding experiences on social media. When limited attention is diverted to rewarding information or experiences, subsequent inhibitory control might be impaired. Recently, researchers have found that high levels of FoMO in individuals may affect executive function, leading to more impulsivity (21). Impulsivity is highly correlated with inhibitory control, and impulse control problems stem from difficulties with inhibitory control (22).

Previous studies have primarily examined inhibitory control through the Go/NoGo task. In this task, participants are typically instructed to respond quickly and accurately to the Go stimulus while refraining from responding to the NoGo stimuli (23). However, it is important to note that Go trials require motor responses, while NoGo trials do not. Consequently, the observed effects of inhibitory control in studies utilizing the Go/NoGo task are susceptible to the influence of response-related processes (24). This effect may be more pronounced in ERP studies, as P3 components are especially sensitive to movement-related potentials (20). Therefore, the present study chose to use a two-choice oddball task that requires participants to respond accurately and quickly to high-frequency standard stimuli and low-frequency deviant stimuli. Because participants must respond to both types of stimuli, the results remain uncontaminated by motor response-related processes. Research has demonstrated that this task is equally effective in inducing inhibitory control as the Go/NoGo task (25–28).

Overall, the present study aimed to examine how FoMO affects inhibitory control. According to the Interaction of Person-Affect-Cognition-Execution (I-PACE) model, researchers have classified inhibitory control into two types: general inhibitory control and stimulus-specific inhibitory control (6). Compared to general inhibitory control, stimulus-specific inhibitory control is often used to explain inhibitory control deficits that occur when facing addiction-related cues (15, 29). Therefore, two studies were conducted using a two-choice oddball task combined with ERPs to explore the impact of FoMO on inhibitory control. Study 1 used a two-choice oddball task to investigate general inhibitory control. We hypothesized that FoMO would affect general inhibitory control. Furthermore, previous studies have demonstrated that relevant cues can lead to a decline in inhibitory control (23, 30). FoMO is often associated with social media (2). Thus, Study 2 used a modified two-choice oddball task with social media-related cues to assess stimulus-specific inhibitory control in social media context. We hypothesized that FoMO would affect stimulus-specific inhibitory control in the social media context, especially for highly social media-related pictures.

2. Study 1

2.1. Methods

2.1.1. Participants

A total of 80 participants with varying degrees of FoMO were recruited. Every participant had a history of over 5 years of social media use. Two participants were excluded due to a large number of ocular artifacts. As a result, the data analysis included 78 participants, consisting of 35 male participants (44.87%). There was no significant difference in FoMO scores between genders ($p > 0.05$) ($M_{male} = 24.91$, $M_{female} = 24.41$). The mean age was 20.31 years (SD = 2.03). Participants received comprehensive instructions and provided written informed consent before the study. The study was approved by the local Institutional Ethical Committee.

2.1.2. Measures and procedure

2.1.2.1. Fear of missing out

FoMO was measured by the Fear of Missing Out Scale (3). This 10-item measure asked participants to rate how true each statement was of their general experiences (1 = "not at all true of me" and 5 = "extremely true of me"). The higher score indicates a greater fear of missing out. Cronbach's α was 0.85 in this study.

2.1.2.2. Two-choice oddball task

Before the experiment, participants completed the necessary scales. Then, they underwent a 20-trial familiarization phase to become acquainted with the task. The formal experiment commenced only when participants achieved 100% accuracy in the practice trials.

The experiment consisted of 5 blocks, each comprising 120 trials. Each trial commenced with the presentation of a small white cross,

and its duration varied randomly between 500 and 1,500 ms. Next, the stimulus was presented. For half of the participants, if the standard stimulus ("W"; 80% of trials) was presented, they were instructed to press the "F" key with their left index finger as quickly as possible. If the deviant stimulus ("M"; 20% of trials) was presented, they were to press the "J" key with their right index finger. The stimulus vanished upon keypress or when 1,000 ms had passed (see Figure 1). The response keys were reversed for the other half of the participants.

2.1.3. Electrophysiological recording

The EEG was recorded using the ANT-NEURO system (Enschede, The Netherlands) with 64 Ag/AgCl electrodes arranged in a 10/20 system layout (AFz serving as ground and CPz serving as the online reference). An electrooculogram (EOG) was recorded by electrodes placed on the outer canthi of the left eye to detect blinks. The impedances of the electrodes were maintained below 5 kΩ. Data were digitized at 500 Hz.

We used the EEGLAB toolbox within the MATLAB software for EEG data analysis. We applied a band-pass filter ranging from 0.01 Hz to 40 Hz to the data. The reference electrode standardization technique (REST) was adopted as a re-reference method (31). Ocular artifacts and head movement were eliminated using independent component analysis (ICA). The EEG data were segmented into epochs, starting with 200 ms before stimulus onset and continuing until 800 ms (i.e., −200 to 800 ms). The period of 200 ms pre-stimulus was used as the baseline to align ERP amplitude. Any trials displaying ERP sweeps with amplitudes exceeding ±80 μV were excluded from the analysis.

To separate the inhibitory control components, the ERPs under the two stimuli were subtracted (deviant − standard) to obtain the difference waves between the two stimulus conditions. Based on the previous studies (12, 16, 23) and the observation of the grand-averaged ERP waveforms and topographic maps (see Figures 2A,B), we analyzed the mean amplitudes of the frontal N2 and parietal P3. The N2 was measured using the mean amplitude at the electrode points of the Fz, Cz, and FCz within a time window of 260–360 ms. P3 was measured using the mean amplitude at the Pz electrode point within a time window of 380–550 ms.

2.1.4. Statistics analysis

2.1.4.1. Behavioral analysis

A repeated-measures ANOVA with stimulus type as a within-subject factor was performed for accuracy (ACC) and reaction times (RTs) respectively. The ACC cost was calculated as the difference in ACC between standard and deviant trials (standard – deviant). The RT cost was calculated as the difference in reaction time between deviant and standard trials (deviant – standard). Higher values of both ACC cost and RT cost may indicate a decline in inhibitory control.

2.1.4.2. ERP analysis

A repeated-measures ANOVA was used to compare the mean amplitudes of the N2 and P3 components. For N2, the two within-subject variables were trial type (standard and deviant) and the three electrode points (Cz, Fz, and FCz). For P3, the two within-subject variables were trial type (standard and deviant) and the electrode point (Pz).

All data analyses were performed using SPSS 25.0; Bonferroni correction was used to correct for multiple comparisons in *post-hoc* tests. All statistical values were reported with Greenhouse–Geisser corrections.

3. Results

3.1. Behavior results

3.1.1. ACC

The repeated-measures ANOVA revealed a significant main effect for trial type [$F(1, 77) = 78.85$, $p < 0.001$, $\eta_p^2 = 0.51$]. The ACC of the deviant stimuli (95.19%) was significantly lower than that of the standard stimuli (99.27%).

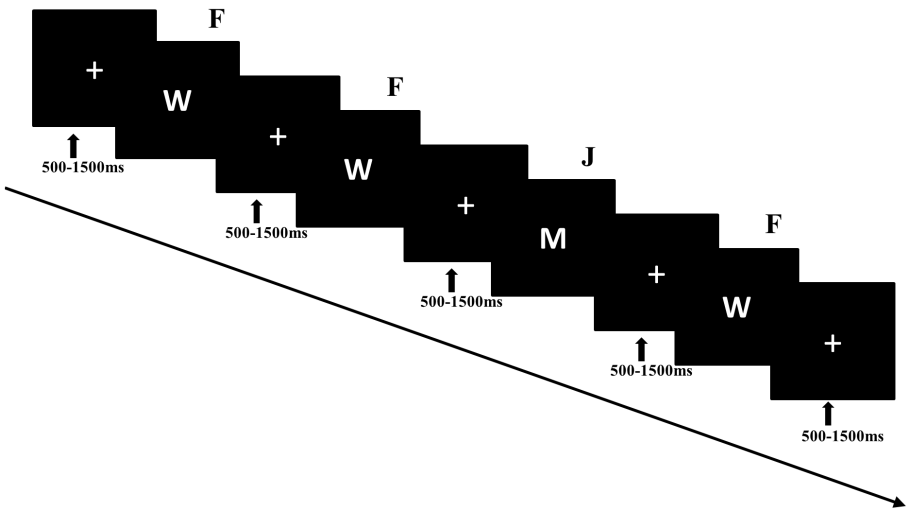

FIGURE 1
Sequence of events in the experimental trial and an example of standard stimuli and deviant stimuli. Each trial presented a single stimulus.

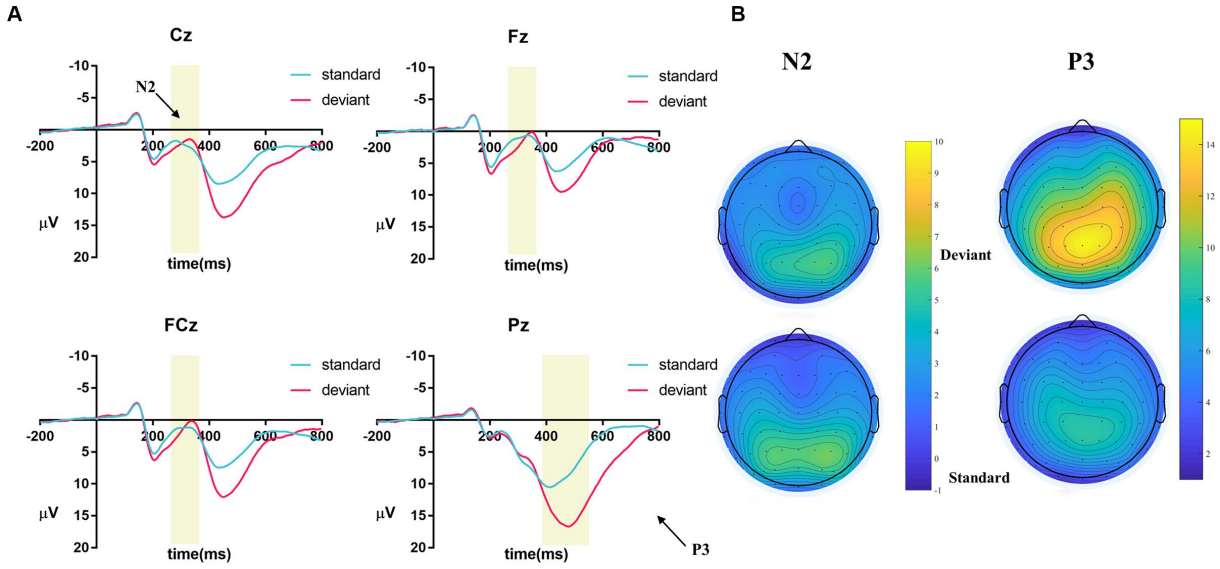

FIGURE 2
(A) ERPs in different picture types (deviant and standard) at electrode points (Fz, Cz, FCz, and Pz); **(B)** topographic maps for N2 (260–360 ms) and P3 (380–550 ms).

3.1.2. RT

The repeated-measures ANOVA of RT on correct trials showed a significant main effect for trial type [F (1, 77) = 390.76.1, $p < 0.001$, $\eta_p^2 = 0.84$], which indicated faster RT for the standard stimuli (486.35 ms) than that for the deviant stimuli (553.77 ms) (see Figures 3A,B).

Linear regression was used to examine whether FoMO scores could predict ACC cost and RT cost. The results showed that FoMO scores did not significantly predict ACC cost and RT cost (p-values > 0.05) (see Figures 3C,D).

3.2. ERP results

N2 and P3 amplitudes and topographic maps are displayed in Figures 2A,B.

3.2.1. N2 component

The repeated-measures ANOVA revealed that the main effect of trial type was not significant ($p > 0.05$). The main effect of electrode points was significant [F (1, 77) = 12.99, $p < 0.001$, $\eta_p^2 = 0.14$], and the trial type × electrode points was significant [F (2, 154) = 59.13, $p < 0.001$, $\eta_p^2 = 0.43$]. The linear regression was used to examine whether FoMO scores could predict the N2 amplitude (deviant – standard). The results showed that FoMO scores did not significantly predict N2 amplitude (Cz, Fz, and FCz) (p-values > 0.05).

3.2.2. P3 component

The repeated-measures ANOVA revealed that the main effect of trial type was significant [F (1, 77) = 239.32, $p < 0.001$, $\eta_p^2 = 0.76$], suggesting that participants revealed a significantly larger P3 amplitude for the deviant stimuli ($M = 14.67\,\mu V$) than the standard stimuli ($M = 8.47\,\mu V$). The linear regression was used to examine whether FoMO scores could predict the P3 amplitude (deviant – standard). The results showed that FoMO scores did not significantly predict P3 amplitude (Pz) ($p > 0.05$).

4. Discussion

Based on the current study, no effects of FoMO on general inhibitory control have been observed at both behavioral and electrophysiological levels. The N2 reflects the conflict monitoring of irrelevant information (32). In Study 1, the difference in N2 amplitude between the two stimulus types was not significant. Simplified stimuli may not evoke their concerns about missing out on rewarding information or experiences. Previous research has demonstrated that relevant cues can lead to a decline in stimulus-specific inhibitory control (23, 33). FoMO is often associated with social media use and constant exposure to others' activities and achievements (10). Study 2 added social media-related cues to further examine the effect of FoMO on stimulus-specific inhibitory control.

5. Study 2

5.1. Methods

5.1.1. Participants

Seventy-eight participants were included in the data analysis, among whom six were excluded due to a high error rate and a large number of ocular artifacts. As a result, 72 participants were included in the data analysis, which comprised 34 male participants (47.22%). The mean age was 20.42 years (SD = 2.08).

5.1.2. Materials

The stimuli consisted of two types: a natural scene of a lamp served as the standard stimulus (70%). The deviant stimuli comprised

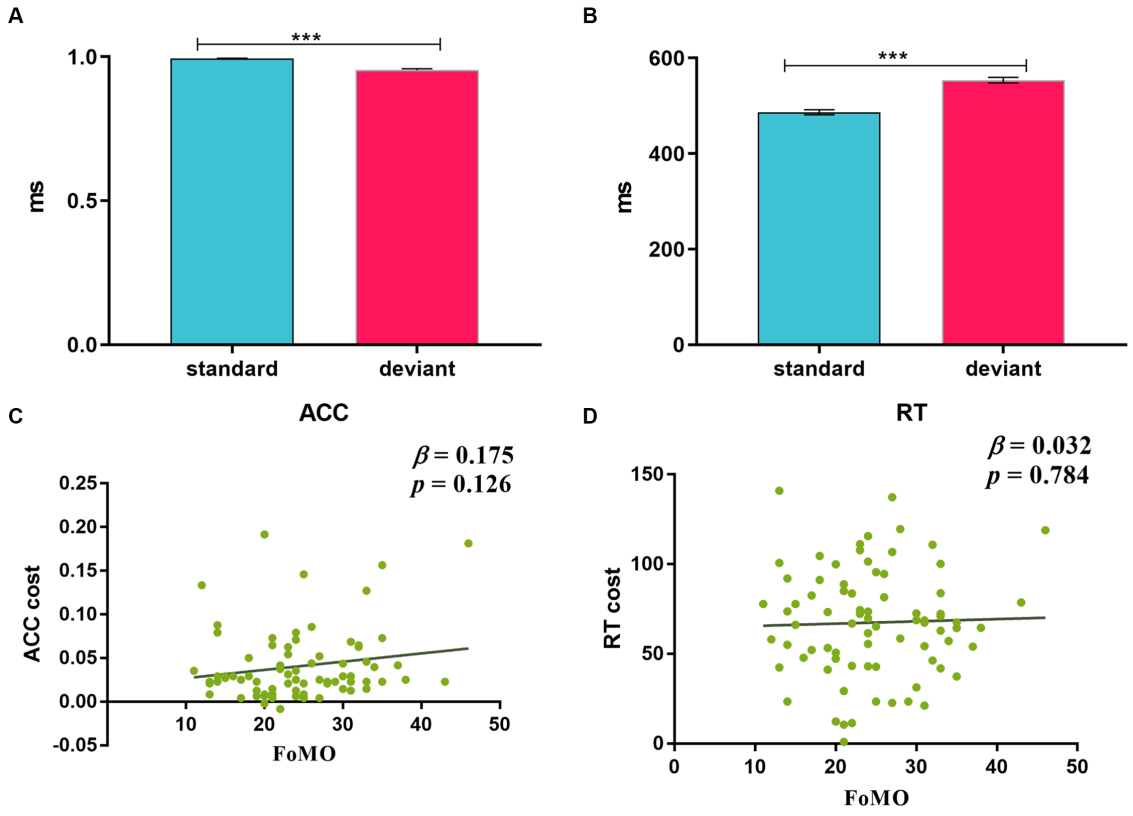

FIGURE 3
(A,B) ACC and RT for standard and deviant stimuli; **(C,D)** regression analyses between FoMO and ACC cost and RT cost. Bars represent the standard error of the mean, the same as below.

TABLE 1 Scores of stimuli pictures ($M \pm SD$).

Rating items	Neutral	HSM	LSM
Valence	5.45 ± 0.63	5.44 ± 0.79	5.39 ± 0.46
Arousal	4.11 ± 0.81	4.54 ± 1.03	4.10 ± 0.80
Familiarity	5.43 ± 1.16	5.60 ± 1.85	4.87 ± 1.57
Social media relevance	2.63 ± 0.68	6.28 ± 1.08	5.26 ± 0.70

three kinds of pictures: high social media (HSM; 10%), low social media (LSM; 10%), and neutral pictures (10%).

Each category contained 40 pictures (260 × 260 pixels). The neutral pictures were sourced from the International Affective Picture System (IAPS). The HSM stimuli comprised icons related to HSM (e.g., WeChat and TikTok). The LSM stimuli comprised icons related to LSM (e.g., Map and Music Player). Before the formal experiment, 36 additional participants (16 male participants, $M_{age} = 21.97 \pm 2.71$ years) were recruited to rate each picture on valance (1 = very unpleasant; 5 = no apparent pleasant or unpleasant experience; and 9 = very pleasant), arousal (1 = very relaxing and 9 = very exciting), familiarity (1 = very familiar and 9 = very unfamiliar), and social media relevance (1 = not at all relevance and 9 = very relevance) on a 9-point scale. Based on these ratings, 30 pictures were selected for each category in total. The scores for the picture types are presented in Table 1.

The repeated-measures ANOVA revealed that the main effects of valence, arousal, and familiarity were not significant (p-values > 0.05). The main effect of social media relevance was significant [F (2, 58) = 166.01, $p < 0.001$, $\eta_p^2 = 0.85$]. *Post-hoc* analyses revealed that social media relevance scores were higher for the HSM pictures than for the LSM and neutral pictures.

5.1.3. Measures and procedure

Participants performed 20 trials prior to the experiment. The formal experiment began only when performance on the practice trials was 100% accurate.

In the present study, a modified oddball task was employed. The experiment consisted of 5 blocks, each comprising 120 trials. Each trial began with a small white cross displayed for 300 ms. A blank screen was then presented for a randomly varying duration between 500 and 1,500 ms. The picture stimulus then appeared. When the standard picture appeared, the participants needed to quickly and accurately press the "F" on the keyboard with their left index finger, and when the deviation picture appeared, they needed to press the "J" key with their right index finger (keyboard keys were balanced between participants). The stimulus picture disappeared after the key press or if 1,000 ms elapsed. Each response was followed by 1,000 ms of a blank screen (see Figure 4).

5.1.4. Statistics analysis

5.1.4.1. Behavioral analysis

A repeated-measures ANOVA with stimulus type as a within-subject factor was performed for ACC and RT. For deviant stimuli, picture type was analyzed as a within-subject factor for ACC and RT.

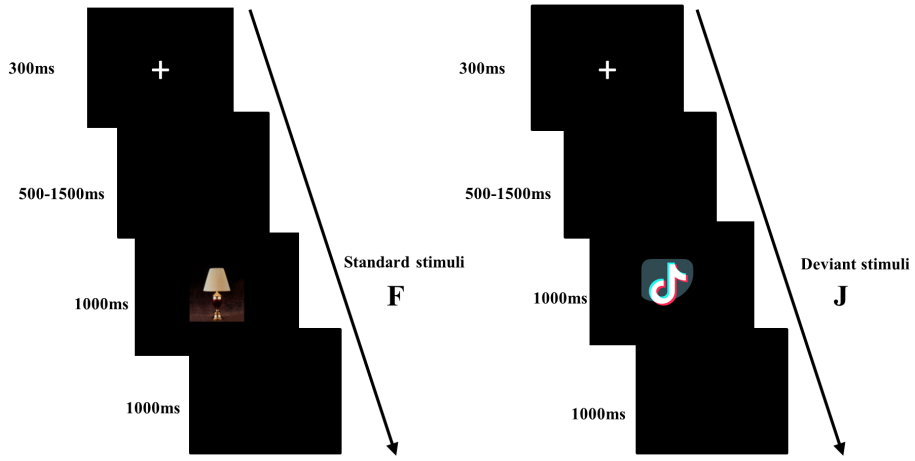

FIGURE 4
Sequence of events in the experimental trial and an example of standard stimuli and deviant stimuli.

5.1.4.2. ERP analysis

A repeated-measures ANOVA was used to compare the mean difference amplitudes of the N2 and P3 components. For N2, the two within-subject variables were picture type (HSM, LSM, neutral) and the three electrode points (Cz, Fz, and FCz). For P3, the two within-subject variables were picture type (HSM, LSM, and neutral) and the electrode point (Pz).

All data analyses were performed using SPSS 25.0; Bonferroni correction was used to correct for multiple comparisons in *post-hoc* tests. All statistical values were reported with Greenhouse–Geisser corrections.

6. Results

6.1. Behavior results

6.1.1. ACC

The repeated-measures ANOVA revealed a significant main effect for trial type [F (1, 71) = 22.19, $p < 0.001$, $\eta_p^2 = 0.24$]. The ACC of the deviant stimuli (97.13%) was significantly lower than that of the standard stimuli (98.41%). In the deviant stimuli, there was a significant main effect for picture type [F (2, 142) = 12.57, $p < 0.001$, $\eta_p^2 = 0.15$]. The ACC in the conditions of HSM (97.64%) and LSM (97.59%) stimuli was higher than those of neutral stimuli (96.16%).

6.1.2. RT

The repeated-measures ANOVA of RT on correct trials showed a significant main effect for trial type [F (1, 71) = 553.49.1 $p < 0.001$, $\eta_p^2 = 0.89$], with longer RT on correct trials for deviant stimuli (539.78 ms) than on those for standard stimuli (453.93 ms). For deviant stimuli, there was a significant main effect for picture type [F (2, 142) = 149.23, $p < 0.001$, $\eta_p^2 = 0.68$]. The RTs in the condition of HSM (529.55 ms) and LSM (531.55 ms) stimuli were lower than that of neutral stimuli (558.25 ms) (see Figures 5A,B).

Linear regression was used to examine whether FoMO scores could predict ACC cost and RT cost. The results showed that FoMO scores positively predicted ACC cost and RT cost ($\beta = 0.28$, $t = 2.43$, $p < 0.05$, $\beta = 0.25$, $t = 2.20$, $p < 0.05$) (see Figure 6A). For social media stimuli, the results showed that FoMO scores positively predicted ACC cost and RT cost for HSM ($\beta = 0.29$, $t = 2.49$, $p < 0.05$, $\beta = 0.25$, $t = 2.15$, $p < 0.05$). FoMO scores only positively predicted RT cost for LSM ($\beta = 0.29$, $t = 2.53$, $p < 0.05$) (see Figures 6B,C). For neutral pictures, FoMO scores only positively predicted ACC cost ($\beta = 0.26$, $t = 2.21$, $p < 0.05$).

6.2. ERP results

N2 and P3 amplitudes (deviant – standard) and topographic maps are displayed in Figures 7A,B.

6.2.1. N2 component

The repeated-measures ANOVA revealed that the main effect of trial type was significant [F (2, 142) = 430.28, $p < 0.001$, $\eta_p^2 = 0.86$]. *Post-hoc* analyses revealed that N2 amplitude was larger for the neutral picture ($M = -7.08\,\mu V$) than for the LSM picture ($M = 1.44\,\mu V$) ($p < 0.001$) and larger for the LSM picture than the HSM picture ($M = 2.33\,\mu V$) ($p < 0.01$). The main effect of electrode points was significant [F (2, 142) = 12.55, $p < 0.001$, $\eta_p^2 = 0.15$], and the trial type × electrode points was significant [F (4, 284) = 23.81, $p < 0.001$, $\eta_p^2 = 0.25$]. Furthermore, the linear regression was used to examine whether FoMO scores could predict the N2 amplitude (deviant – standard). The results showed that FoMO scores positively predicted N2 amplitude for HSM (Cz, Fz, and FCz) ($\beta = -0.30$, $t = -2.66$, $p < 0.05$; $\beta = -0.27$, $t = -2.38$, $p < 0.05$; $\beta = -0.29$, $t = -2.53$, $p < 0.05$, and LSM, $\beta = -0.43$, $t = -4.03$, $p < 0.001$; $\beta = -0.40$, $t = -3.66$, $p < 0.001$; $\beta = -0.43$, $t = -3.96$, $p < 0.001$) (see Figure 8A). FoMO scores did not significantly predict N2 amplitudes in neutral pictures.

6.2.2. P3 component

The repeated-measures ANOVA revealed that the main effect of picture type was significant [F (2, 142) = 101.40, $p < 0.001$, $\eta_p^2 = 0.59$]. *Post-hoc* analyses revealed that P3 amplitude was larger for the LSM picture ($M = 6.89\,\mu V$) than for the neutral picture ($M = 4.02\,\mu V$) ($p < 0.001$) and larger for the HSM picture ($M = 7.75\,\mu V$) than the LSM

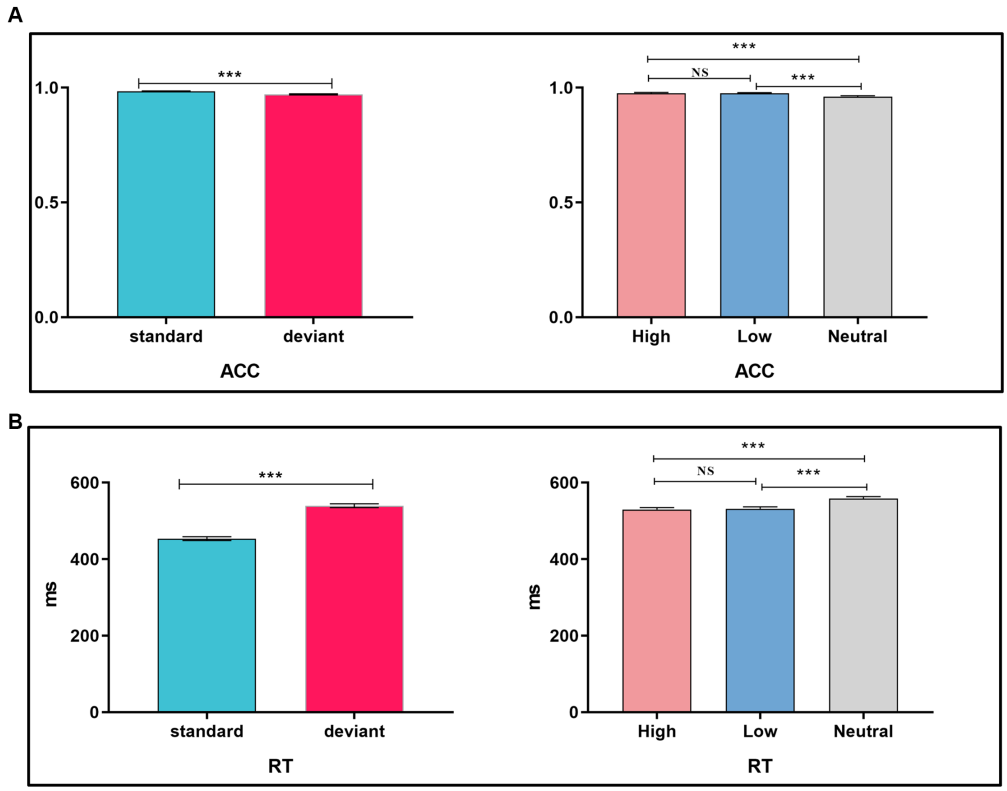

FIGURE 5
(A) ACC for trial types (standard and deviant) and picture types (high, low, and neutral); **(B)** RT for trial types (standard and deviant) and picture types (high, low, and neutral).

picture ($p < 0.001$). The linear regression was used to examine whether FoMO scores could predict the P3 amplitude (deviant – standard). The results showed that FoMO scores positively predicted P3 amplitude for HSM (Pz) ($\beta = -0.25$, $t = -2.13$, $p < 0.05$) and LSM ($\beta = -0.24$, $t = -2.04$, $p < 0.05$) (see Figure 8B), but FoMO scores did not significantly predict P3 amplitude in neutral pictures ($p > 0.05$).

7. Discussion

The current study revealed that FoMO undermines inhibitory control within the context of social media. As FoMO scores increased, participants showed larger N2 amplitude and smaller P3 amplitude when exposed to social media-related pictures. Individuals with FoMO direct limited cognitive resources toward relevant cues, resulting in decreased inhibitory control (33). These results were consistent with the findings that relevant cues are more likely to attract the attention of individuals and further generate poor inhibitory control (23).

8. General discussion

This study aimed to investigate how FoMO affects inhibitory control in the context of social media through two studies. The findings revealed that FoMO had no significant impact on general inhibitory control. However, within the context of social media, participants exhibited a decline in stimulus-specific inhibitory control as their FoMO scores increased, particularly when exposed to HSM pictures. Importantly, significant findings were observed at the electrophysiological level. When faced with different cues, participants showed smaller N2 amplitude and larger P3 amplitude under the cues of social media-related pictures compared to neutral pictures. Additionally, the N2 amplitude of social media-related pictures increased while the P3 amplitude decreased as the FoMO scores increased.

In Study 1, no significant effects of FoMO on general inhibitory control were observed at both the behavioral and electrophysiological levels. This result contradicts our first hypothesis. Nonetheless, in Study 2, when social media-related cues were introduced, we observed a significant and positive relationship between FoMO scores and both ACC cost and RT cost. This implies that as FoMO scores increase in the context of social media, inhibitory control diminishes, particularly in the HSM condition. This finding indicates that individuals with FoMO may not be notably affected by simple stimuli, such as the letters "W" and "M" used in Study 1. Previous research indicates that highly anxious individuals perform poorly on cognitively demanding tasks that require efficient cognitive processing (34, 35). Consequently, in Study 2, the inclusion of social media-related cues increased the task difficulty, and individuals with FoMO were required to allocate top-down attentional control resources to complete the task. This increased cognitive demand resulted in reduced inhibitory control.

On the electrophysiological level, the present study found that the N2 amplitude of social media pictures was smaller than that of neutral

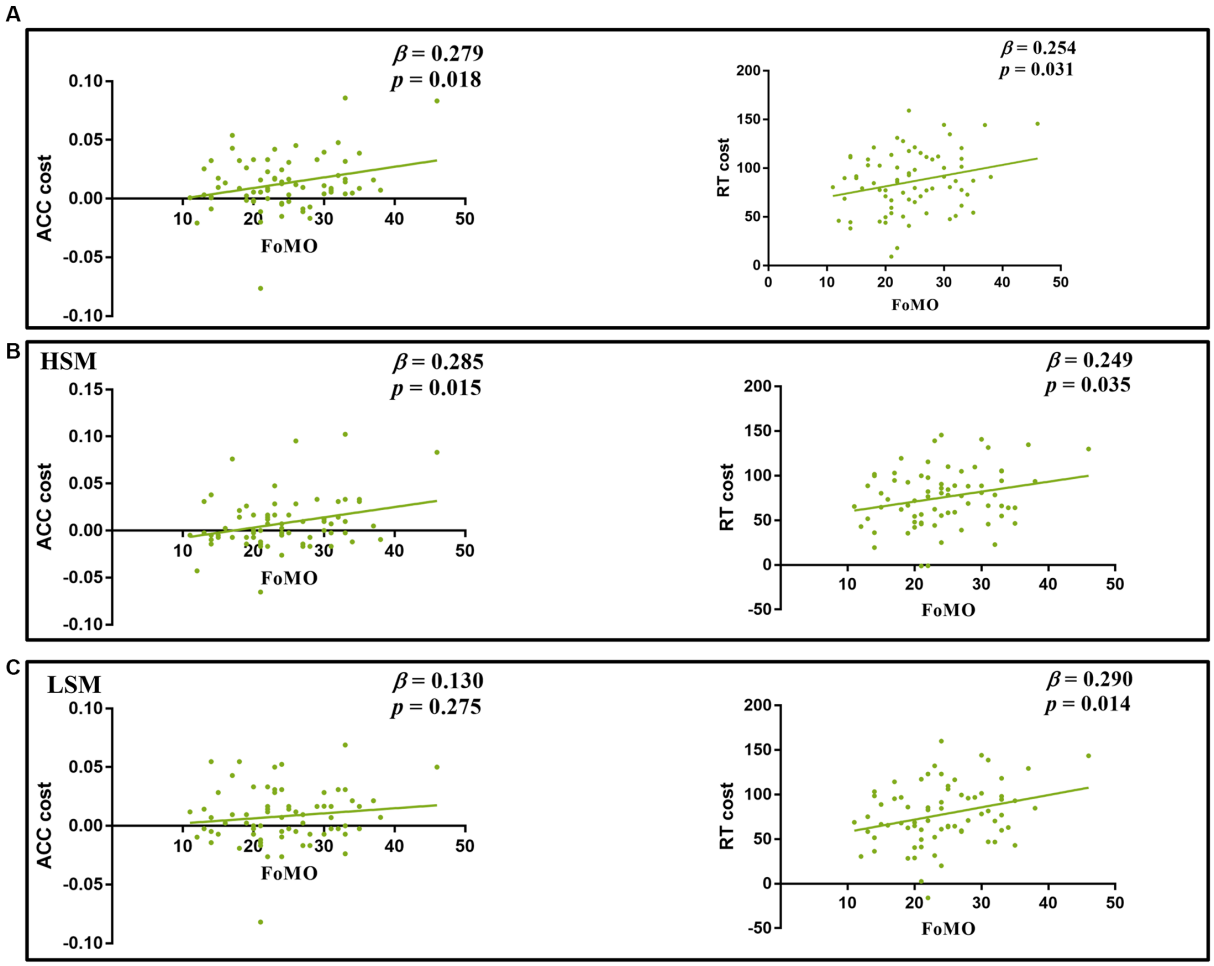

FIGURE 6
(A) Regression analyses between FoMO and ACC cost and RT cost; **(B,C)** regression analyses of FoMO with ACC cost and RT cost in HSM and LSM pictures.

pictures, and the N2 amplitude of HSM pictures was smaller than that of LSM pictures. The N2 amplitude served as an indicator of cognitive resources expended during conflict detection (36). These findings suggest that individuals invest fewer cognitive resources in the early conflict detection stage when confronted with social media pictures. A previous study suggested that Internet addiction disorder students had lower cognitive resources in the conflict detection stage than the normal group (smaller N2 amplitude). This is because they had to engage in more cognitive endeavors to complete the inhibition task in the late stage (37). This is consistent with our findings. Furthermore, in this study, the P3 amplitude of social media pictures was larger than that of neutral pictures, and the P3 amplitude of HSM pictures was larger than that of LSM pictures. The increase in P3 amplitude indicated that more cognitive resources needed to be consumed to invest in the response process (28). This illustrates that when confronted with social media pictures, especially HSM pictures, they must allocate more cognitive resources to effectively inhibit the motor system in the later stages of inhibitory control.

Importantly, the results of the present study revealed a significant correlation between FoMO scores and the amplitudes of N2 and P3. As FoMO scores increased, the N2 amplitude increased and the P3 amplitude decreased, specifically for social media pictures but not for neutral pictures. This finding is consistent with the attentional control theory (5), which suggests that the inhibitory function of anxious individuals is particularly inefficient in the presence of distractors. High-anxious individuals are more negatively affected by distractors compared to low-anxious individuals (4). High-trait anxiety individuals showed a larger N2 amplitude than low-trait anxiety individuals, which means that high-trait anxious individuals use more cognitive resources to perform the monitoring process (38). The present study demonstrated that individuals with higher levels of FoMO consume more cognitive resources in the early conflict detection process of inhibitory control when confronted with social media-related cues (larger N2). However, as cognitive resources were limited (33), excessive consumption of resources during the early stage of conflict monitoring can lead to insufficient resources during the motor inhibition stage (smaller P3). Consequently, it leads to a decrease in the inhibitory control of the individual. When social media cues are added, individuals show a decrease in deficient stimuli-specific inhibitory control.

Several limitations require further attention. First, the study focused on measuring inhibitory control in young adults, specifically those around 20 years old. This may limit the generalizability of the findings to other age groups. A previous study found that FoMO did

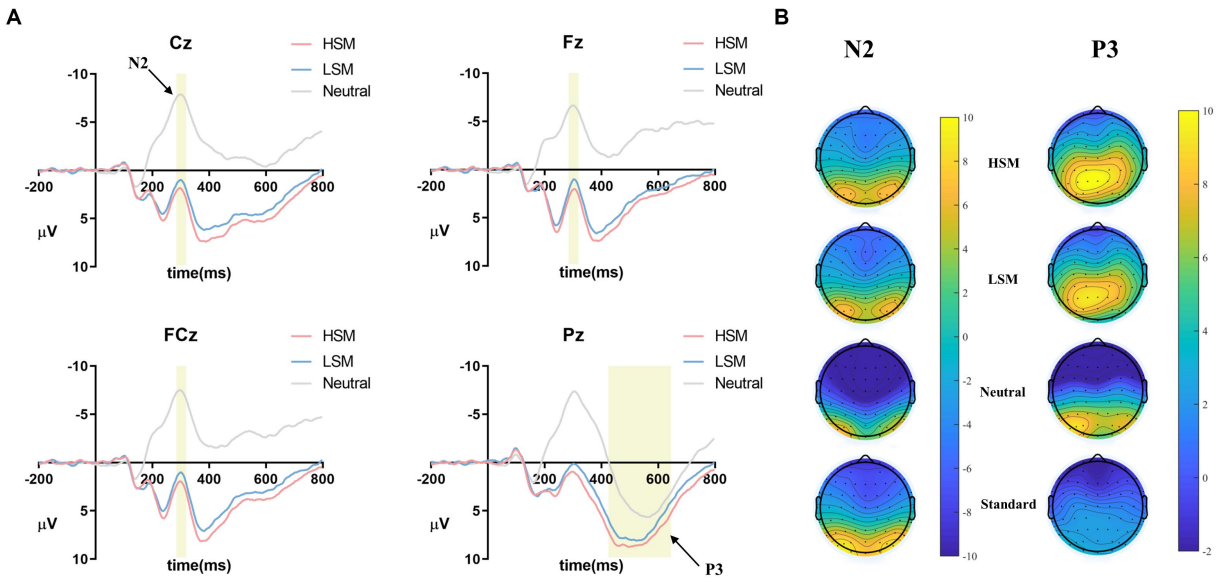

FIGURE 7
(A) ERPs in different picture types (deviant – standard) at electrode points (Fz, Cz, FCz, and Pz); **(B)** topographic maps for N2 (280–320 ms) and P3 (420–650 ms).

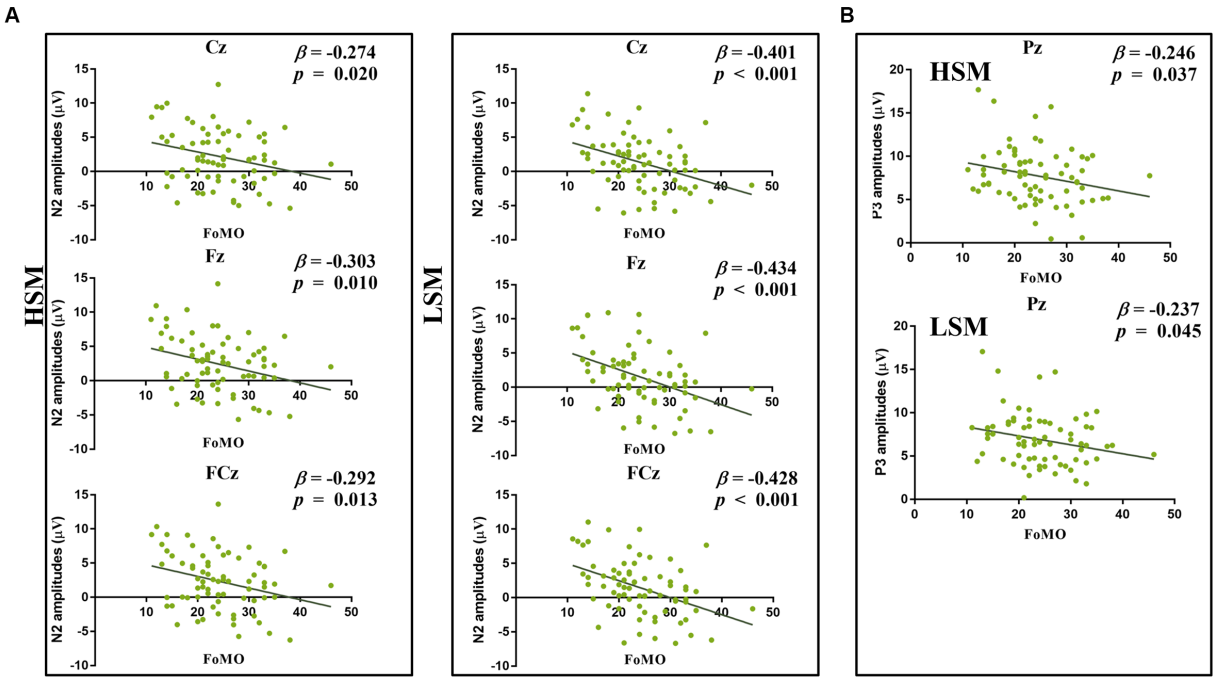

FIGURE 8
(A) Regression analyses between FoMO and N2 amplitudes (Cz, Fz, and FCz); **(B)** regression analyses between FoMO and P3 amplitudes (Pz).

not appear in a particular age group (39). Thus, the generalizability of the results of the current study will have to be tested in future studies. Second, the use of self-report measures to assess FoMO may introduce potential biases and subjectivity. Future studies could incorporate more objective measures to complement self-reported data. Third, the present study found that the effect of FoMO on inhibition in the social media context and the adverse effects of anxiety on processing efficiency depended on inhibition and shifting (5). Shifting, as a component of executive functions, also plays a crucial role in cognitive processes. Thus, future research could further investigate the effects of FoMO on shifting in the social media context. Furthermore, there are some potential issues in the material selection in Study 2, such as the limited distinctions between high and low social media stimuli. Future studies could perhaps replace low social media stimuli with stimuli

unrelated to social media to increase the differentiation among the three kinds of pictures.

9. Conclusion

The present study has revealed that FoMO had an effect on stimulus-specific inhibitory control. Specifically, FoMO undermines inhibitory control in the social media context. As FoMO scores increased, individuals' inhibitory control abilities were found to decrease when exposed to social media-related cues. FoMO exerts an impact on inhibitory control by consuming more cognitive resources during the early conflict detection stage, while the later stages of the inhibitory process suffer from insufficient cognitive resources. These findings provide insights into the underlying mechanisms through which FoMO influences inhibitory control processes in the social media context.

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 humans were approved by Institute of Brain and Psychological Sciences, Sichuan Normal University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YX: Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. YT: Conceptualization, Funding acquisition, Writing – review & editing.

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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

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Stakeholders' views and opinions on existing guidelines on "How to Choose Mental Health Apps"

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Background: Mental health Applications (Mhealth Apps) can change how healthcare is delivered. However, very little is known about the efficacy of Mhealth Apps. Currently, only minimum guidance is available in Assessment and Evaluation Tools (AETs). Therefore, this project aims to understand AET developers' perspectives and end users' experiences and opinions on "how to choose a Mhealth App".

Objective: The primary objectives were: (1) obtaining stakeholder's opinions and experiences of development and use of AETs for Mhealth Apps, their weaknesses and strengths, and barriers in their implementation of Mhealth Apps; (2) the experiences of App users, their analyzation and, obstacles in the use of apps; and (3) to quantify themes related to choosing a Mhealth App.

Methods: This qualitative study, used a sampling method to recruit six stakeholders (one App developer, two AET developers, an individual with lived experience of mental health illness, and two physicians) who were interviewed using a topic guide. These were examined by researchers (CT, WK, & FN) using thematic content analysis. Additionally, an anonymous online survey of 107 individuals was conducted.

Findings: Our analyses revealed six main themes: (a) needs and opportunities; (b) views on Mhealth apps; (c) views & opinions on AETs; (d) implementation barriers; (e) system of evaluation and; (f) future directions. The first key concept was, all stakeholders agreed that Apps could significantly impact mental health and that end-users were unaware of mental health AETs and Apps. Secondly, due to commercial interests, end-users reliability of App evaluations requires clear conflict-free guidelines. Thirdly, AETs should be evaluated and developed through a rigorous methodology. Finally, stakeholders shared insights into future developments for AETs and Mhealth Apps. Additionally, online survey respondents chose a "health professional" as their preferred source of guidance in selecting a Mhealth app (84%) and best suited to develop guidelines (70%).

Conclusion: The interviews and survey highlight the need for Mhealth Apps to be regulated and the importance of health professionals' engagement in the implementation process. Similarly, without well-defined roles for App evaluations

within the health care system, it is unlikely that AETs will have wider spread use and impact without risk.

KEYWORDS

mobile Apps, mental health, digital health, guidelines, evaluation

Introduction

Social distancing and changes in practice around COVID-19 have forced health providers worldwide to provide services through online platforms, thus acting as a catalyst to raise awareness, interest, and uptake of mobile health applications (mHealth Apps) (1). In addition, some countries have reported changes in legislation and policy to promote telemedicine (2, 3). As a result, the demand for mHealth Apps is strong. A recent public survey found that 76% of 525 respondents would be interested in using their mobile phones for self-management and self-monitoring of mental health if the service was free (4). In a similar survey of physicians' attitudes toward mobile health (MHealth), most expressed hope that technology could be very effective in their clinical practice (5).

There are currently more than 10,000 Apps created explicitly for mental or behavioral health (6) out of 318,000 health Apps (7). The primary function of these Apps is to target the medical disease or disorder in terms of prevention, management, and treatment of the health issues. However, as the numbers of the mHealth Apps increase, so do the apprehensions surrounding the safety and effectiveness of these Apps (8). Considering medical devices and pharmaceuticals undergo a thorough assessment to be licensed, the equivalent evaluation is beginning to be expected of mHealth Apps. In healthcare, this is necessary to guarantee any reputable technology's effective and safe operation (7).

Mental health applications (Mhealth Apps) may play an essential part in the future of mental health care (4) by making mental health support more accessible (9). However, there is insufficient evidence for the effectiveness of these Apps. A recent publication reported that only 3.4% of Mhealth Apps were included in research studies to justify their claims of effectiveness, with most of that research undertaken by those involved in developing the App (10). It has been observed that a clinically relevant App for people living with depression becomes unavailable and deleted from App stores every 2.9 days (11). Similarly, App stores require regular updates, making it challenging to keep track of a quickly evolving field (12). Furthermore, people generally stop using a Mhealth App if they are not equipped with any guidance from a clinician (13). Along with a study reporting that within 7 days of downloading an App, over 56% of users uninstall them (14). This mix of potential and problems means there must be clear guidelines on "How to choose a Mhealth App".

Mental health interventions and Mhealth Apps broadly vary significantly in their use. Therefore, evidence-based guidelines that have been established for mental health interventions do not apply to Apps. Presently, there is very limited regulation on the growth and reporting of Mhealth Apps, from their effectiveness, side effects, privacy and security, reporting, and scientific examination (15). However, due to these factors, the need to regulate Mhealth Apps increases (16). So far, only the FDA has approached a form of regulation with regulatory guidelines [the Digital Health Software Precertification (Pre-Cert) Program]. This program recognizes the unique and rapidly changing aspects of mHealth Apps and aims to streamline the regulatory oversight of software-based medical devices (17).

Several Assessment and Evaluation Tools (AETs) (e.g., frameworks, guidelines, rating systems, or App libraries) have been developed internationally (18–22). However, these initiatives are not without issues. For example, the NHS Apps Library, which assessed Apps against a defined set of criteria, was released but quickly rolled back due to public outcry following news that highlighted privacy and security gaps in many of the Apps (23). In addition, many AETs rely on expert consensus, which can be opaque and difficult to understand for both users and clinicians (24). There are also significant inconsistencies in their outcomes. For example, a study of three different ranking systems (PsyberGuide, ORCHA, and MindTools.io) demonstrated a lack of correspondence in evaluating top-rated Apps, indicating weak reliability (6).

Mhealth Apps present opportunities to improve access to high-quality mental health care. However, there is only limited evidence for their effectiveness, side effects, and cost-effectiveness (25). Therefore, as the numbers of Mhealth Apps grow, so does the need to regulate the field so that App users and referring clinicians can have sufficient information to choose an App. Therefore, we conducted a qualitative study to explore stakeholders' views and opinions and their understanding of "how to choose a Mhealth App." Our stakeholders included an individual with lived experience of a mental health illness, two an AET developers, two physicians, and an App developer. The themes that emerged from the qualitative interviews were utilized to develop a survey that identified themes on how App users choose Mhealth App.

Aim

We aimed to understand stakeholders' opinions and experiences on how to choose a Mhealth App. The objectives were to explore the stakeholder's views and experiences of existing guidelines for choosing Mhealth Apps, their weaknesses and strengths, barriers in their implementation, and experiences when using the app, including their decision process and barriers in this space.

Methodology

Qualitative study design and setting

This qualitative study consisted mainly of semi-structured interviews with stakeholders. Semi-structured interviews with

open-ended questions, prompts, and facilitatory statements are considered to be the most suitable techniques for this study. These types of interviews provide researchers more control over the topics discussed without limiting the range of responses to each question, as is the case in structured interviews or questionnaires that use closed-ended questions (26).

Sample recruitment

Key stakeholders were purposely recruited for their knowledge and experience developing AETs or Mhealth Apps and their experience using Mhealth Apps. Clinicians who have considered using Mhealth Apps in their practice were also consulted. Stakeholders were selected based on advice from experts in the field and through our network. The rationale was employing the maximum variation strategy, a convenience sampling method that maximizes sample heterogeneity to capture a breadth of views and perspectives (27). We first made a list of likely participants, who were then were contacted via email invitation and followed up by telephone. Those who consented were invited to an interview.

Development of semi-structured interviews

We initially developed a list of areas that needed exploration through a brainstorming process. It was finalized in a group meeting conducted through Cisco WebEx. In addition to open-ended questions, prompts were agreed on to explore further areas of interest. It was considered essential that the participant's views be understood in the context of their background, so additional questions were added for each group of stakeholders. Interviews were conducted by members of the research team (CT and WK) who had prior experience with qualitative interviews. FN provided supervision throughout this process.

Data collection

Participants were informed of the procedures and their rights to withdraw from the interview process at any time. Interviews lasting 45 min were conducted virtually using Cisco WebEx and recorded with the participant's consent. Participants were informed of privacy, and related risks before the interview and that identifiable information would be removed from the data except for a broad description of their background, such as "App developer", that would be included in the analysis and results. Interviews were conducted between January 11th and 29th, 2021.

Each interview was fully transcribed and checked for accuracy. Transcription was started shortly following the completion of each interview. Participants were contacted if a response needed further clarification. Access to data was limited to the research team. The interview transcripts were returned to participants for comments, verification, and clarity concerning queries that arose from the analysis stage.

Data analysis

Data were analyzed using thematic content analysis (28). This rationale was most appropriate to explore patterns across qualitative data. Each researcher (FN, CT & WK) analyzed the interview data multiple times to identify emerging themes and categories. We followed the principle of "emergent design" (27) when the respondent raised the issues that required further exploration. These issues were then tested appropriately in subsequent interviews with the participants. We also contacted participants by telephone to clarify areas of uncertainty when the data was analyzed.

Each interviewee was assigned a number for transcription and reporting. The data was primarily descriptive, with most themes emerging in response views. Two team members coded data separately to improve the reliability of the analysis. Finally, the data was reorganized into broader themes (e.g., views and opinions on Mhealth Apps) and categories (e.g., how Apps are developed and chosen). The authors held regular meetings throughout data analysis, facilitating the further exploration of participants' responses, discussion of deviant cases, and agreement on recurring themes. Two authors (CT and WK) independently analyzed the data using a thematic approach. When consensus was not achieved, FN helped reach an agreement.

Quotes are presented according to theme across multiple interviewees to highlight consistency amongst stakeholders and present contrasting viewpoints where applicable. Despite using the term AETs throughout this document, in the earlier stage of this project, the term "evaluative framework" was used in place of AET. As such, it is synonymous with AET in the quotes from key stakeholders.

Study participants

Two interviewers (CT & WK) conducted six interviews with key stakeholders. Stakeholders who took part in our interviews adhere to five broad categories: App Developer (AD) from IT background with 5 years' experience, Physician (P) with no experience in AET or App development or evaluation, Physician Educator (PE) who was involved in development and evaluation of one mental health app in the past, AET Developer (AED) who was from IT background with 15 years' experience, and a Person Living with a Mental health condition (PLM) who had used a mental health app in the past. This person had a diagnosis of bipolar affective disorder. Two AET developers were interviewed to understand their experiences and opinions better. The App developer worked with a hospital. Participant's age ranged between 32 and 48. Both physicians were psychiatrists.

Online survey study design and setting

Sample recruitment

The rationale of this anonymous online survey is to confirm the findings of the qualitative studies in a larger sample size. People were asked to participate if they currently used, or had

previously used, apps. The survey was available for 5 days, from February 17 2021 to February 21, 2021. At the time the study was being conducted, those with lived or current experiences of mental health disorders and illnesses were neither actively sought out nor excluded.

To reach a wide range of participants who are likely to use technology, the survey was promoted on social networks (including Twitter, LinkedIn, and Facebook). We utilized a snowball sampling strategy, requesting retweets' and shares' from both participants and non-participants. Additionally, the original "tweet" on Twitter was' retweeted' on a daily basis. No incentives were offered.

Development of the online survey

The survey consisted of 12 questions. The topics that emerged from the qualitative study covered in the current paper served as the basis for the survey questions, which were prepared collaboratively by the research team. We aimed to obtain a broad picture of how end-users choose Mhealth Apps, which is an important issue for many AETs.

The survey consisted of 12 questions in total. The survey questions were jointly developed by the research team and were based on themes emerging from the qualitative study discussed in the current paper. Questions one through five captured demographic variables of interest, questions six and seven enquired about their past use (and rationale) of apps, questions eight and nine enquired about their existing process for choosing an app, while questions ten through twelve enquired about (a) who they would trust (e.g., hospital, government, clinician, IT app developer, etc.) to develop an app they would use; (b) what factors influence their app selection process, and (c) who they would trust to provide guidelines, or a tool, to choose an app. No personal details were collected.

Data analysis

We used SPSS v27 to analyze data. Descriptive statistics was use to describe data. Where the data were nonparametric, we used the Chi-square test to look at the frequencies of responses.

Results

We identified six broad themes: (a) needs a opportunities; (b) views on MHealth Apps; (c) views and opinions on Mhealth App AETs; (d) implementation barriers; (e) system of evaluation; (f) future directions. Here we describe these themes and the categories under each theme.

Needs and opportunities

Mental health apps

With smartphone and web technology expansion, Mhealth Apps have exponentially increased in popularity and usage among service users, health service providers, and researchers in the past 10 years. Comments by our stakeholders reflected the potential of this technology to expand service delivery, improve clinical integration, and for the potential to further individualize the App experience for users with the frequently improving technology.

> One participant reflected on increasing demand for advice, *"Well, people do come and ask, what are the resources [Mhealth Apps]? Because it's an issue [lack of resources], you do wish that you had more resources we could recommend to people." (P)* Another participant highlighted the potential for improving access to psychotherapies through Mhealth Apps, "*One of the challenges, of course, is with someone who may not have the resources, may live in an area there's not a lot of clinicians, being able to access CBT might be difficult" (PE).*

Although not directly referenced in most interviews, the backdrop of these interviews is amongst the COVID-19 pandemic in which the context of comments surrounding the Mhealth App comes amid stay-at-home orders, challenges in face-to-face contact with service providers, and the rise of telehealth. Most interviewees highlighted the potential for mental health apps to present a unique option to integrate with traditional services and provide psychoeducational or therapeutic material when other traditional supports are not available.

> *"I believe there's more urgency now to develop Apps" (P),* another stakeholder said, *"...especially amidst the [COVID-19] pandemic in a time where a lot of services are not readily accessible, and travel is quite challenging. So, for me, I see a lot of promise" (PE).*

AETs (Assessment and Evaluation Tools)

According to AET developers, concerning the rapid evolution of technology and expansion of the Mhealth App space, there seems to be a growing need for oversight in the form of formal AETs. We must move away from the user's reliance on the commercial App Store's rating and review evaluation system. One AET developer said:

> *"If they're intended for therapeutic use, it really needs a higher level of scrutiny because people who need treatment need to get treatment on evidence-based approaches. You wouldn't walk into a cancer clinic and expect to get a treatment that hadn't been approved by anyone, so why would you (not do that) in the digital space if you need treatment for mental health?" (AED2).*

This same AET developer also expressed concerns about the existing App evaluation systems that might lead to the use of Apps that might not offer what they claim.

> *"The App user may have wasted time thinking that something was therapeutic. So, the idea that we can use crowdsourcing, because people we don't even know who rate it, that gave it five stars, who weren't scientifically trained or medical professionals to evaluate it, those kinds of websites and frameworks are showing up everywhere, and I think it*

> *may mislead people on really that is an effective App that has therapeutic benefits vs. that don't, and that may delay treatments" (AED2).*

Another AET developer further explained that established AETs could help individuals navigate the obscured motivations of App developers in a quickly changing and profit-motivated field.

> *"It's probably the market forces that are determining [the variety and quality of apps]. It's an economic matter. There's not much input from family members, clinicians, patients, even payers. So, it's just the free market that has shown us what a market will support" (AED1).*

Views on mental health apps

App development process

The interviews with our key stakeholders made it apparent that there is an increasing gap between how Apps are currently being developed and their views on how they should be developed to maximize accessibility and effectiveness for users. The primary examples raised were the lack of input from various stakeholders, functionality, language, and App looks.

> The App Developer acknowledged the lack of stakeholder engagement, *"I think it's just getting people involved, and I know it's difficult [for some App developers] to find the right people. Especially if someone isn't in the mental health environment." (AD)* The need to include stakeholders in the App development process was also emphasized by the physician educator, *"[it's so important] the co-development and review or design with a clinician, with expertise in [App evaluation]" (PE).*

Both the App developer and the person who has lived experience of a mental health illness emphasized the need for appropriate use of language in terms of an App's ease of use and its cultural aspects.

> The App Developer stressed the importance of language, *"So, [in some languages] the word for like say schizophrenia or mental health might not be there per se. So, you have to make sure it's closely relevant and stuff like that." (AD)* This was further emphasized by the person who has lived experience of a mental health illness, *"The other thing is the language that's being used. Like, how do they welcome me? How do they talk about mental illness?" (PLM).*

They also spoke about the aspects of the App that matter to them a lot.

> The person who has lived experience of a mental health illness said, *"How it looks [comes first], then functionality. Is it easy for me to find certain things? Those things are important to the experience, the user in my eyes." (PLM)* The App developer raised similar issues, *"...for instance, making sure color contrasts are at a good level, a font size [that helps with] accessibility for websites and Apps" (AD).*

How apps are chosen

Among stakeholders, the primary App users were the person who has lived experience of a mental health illness, for whom most Mhealth Apps are targeted, the App developer (as a Mhealth App user), and the clinicians (in this case, psychiatrists) who are possibly advisors assessing and recommending Apps for use in their clinical practice. Each of these stakeholders stated that user experience, credibility, or validity (i.e., the App is providing what it says it's providing) is of utmost importance. Credibility also extends to the App developer themselves. Do they have a track record of quality Apps, positive feedback, and developed relationships and collaboration with health providers?

Our stakeholder interview with a person with lived experience of a mental health illness was illuminating, specifically the conversation about selecting a Mhealth App. In terms of how they chose the Apps and their initial impressions, they said:

> *"If I'm on the [Google] Play Store, and I'm looking up Mental Health App, or Mental Health Tracker. It's kind of a—which one is the prettiest? Which one is the most eye-catching or that I think is easy to use? That might not be the best one for me, but it's easy to use. At the time when I'm depressed and anxious and all the other stuff I'm dealing with. I just want it to be easy" (PLM).*

They further explained what features they liked the most in an App they used,

> *"Daily reminders, motivating, keeping you accountable like pill tracking and habit tracking put all into one is very helpful. Then looking, engaging, and having fun can be beneficial. Separating it from the medical-looking App is cool." (PLM)* They liked the idea of an animated character, *"I like the idea of having this buddy" (PLM).*

They shared their reasons for trusting the App. They also emphasized the importance of cultural and age-specific issues.

> "*There was mention of it coming from [health services in a Canadian province], so I really did like that it was Canadian mental health. It came from that industry. My experience with it is that what makes this one so different from the ones I've seen is that because it sounds like it's made for younger folks, it's so, I don't want to use the word simple, but it's not as medical" (PLM).*
>
> Finally, they explained the reason for their engagement with the App, *"There's a check-in question every day, and then there are quests you can do, and you can gain points. Frankly, I don't think they go anywhere, but the idea of collecting points really entertained me at the time, and it just made me feel like I can achieve things. What's also great is that there's this motivational messaging that's around it" (PLM).*

On the other hand, the AET developers shared their concern that it may be that Mhealth App users are not carefully selecting an App that best suits them, and this is reflected in recent research showing most Apps are deleted within a week of download (14). One AET developer said:

> *"The reality is that most Apps aren't used beyond the first 2 weeks. Over 95% of them aren't used beyond 2 weeks, and there have been formal studies to show that." (AED2).* This point was also emphasized by the second AET developer who said, *"I think the usability, [one paper] in 2019 shows you 90% of people stop using the App in 10 days. So, the engagement crisis is pretty high" (AED1).*

How apps are chosen- online survey

Two-thirds (67%) of the one hundred and seven survey respondents indicated they have previously used an Mhealth App. Of app users, 37% had used the Mhealth App for a specific mental health problem, and 33% of respondents had used a mHealth App for general wellbeing. The remaining respondents used a Mhealth App for research, did not know, or preferred not to share their reason.

> *In response to the question, "Where do you look to help you choose a mental health app?" most respondents (66%) stated that "app store ratings and reviews" were their source of primary consideration. In terms of important factors that individuals look for in a Mhealth App, the most common response from respondents was "functionality" (83%), followed by "ease of use" (77%), "cost" (69%), and "research evidence" (57%). When responding to the question, who will you trust to produce a mental health app, the most common answer was "a hospital" (68%), followed by "mental health clinician" (62%) and "a government agency" (59%).*
>
> *The survey respondents" overwhelming choice in response to their preferred source for advice in choosing an app was a "health professional" (84%). Finally, when asked who is best suited to develop guidelines for choosing a mental health app, the most common answer was "health professionals' (70%), followed by "university researchers" (59%) and "individuals with lived experience" (43%). Please see Appendix B Figure 1 for participant demographics and Appendix B Figure 2 for details of the last five questions from the survey.*

Concerns around Mhealth apps

Several concerns were raised by the stakeholders, specifically around privacy, data collection, large amounts of text, and issues related to digital equity.

> For example, the person with lived experience of a mental health illness said, *"The thing I didn't love [about the App], was there were a lot of questions, in the beginning, it's a bit of a barrier. For me, it was reading text. It was just a lot of text."* (PLM). They were less concerned about privacy and security, *"I didn't have to create an account [what they liked about the App], which is great. Like I don't want to put in my email, I don't want to put my full name and that kind of stuff. I want to see if this is something that I want to invest my time in before I create a full account and tell you all my information" (PLM).* They further explained their point by saying, *"One thing that always comes up is privacy and where that information goes" (PLM).* Other participants reiterated this last point about privacy, *"I think privacy is the main issue always." (AD), and "I think one of the issues would be privacy" (P). One* physician further discussed the risks and harm as they said, *"Is there a fallout to delivering therapy through this App?" (PE).*

Nearly all the participants discussed the lack of evidence for most Apps and how evidence should be built around the Apps.

> *"Well, I think the work needs to be done, to do some sort of a clinical trial of its effectiveness" (P).* Another participant said, *"I think you never know (for other Apps) the involvement of people if it's evidence-based, research-based" (AD). One* AET developer said, *"The App needs to be evidence-based as an App can be, at least designed by experts having face validity." (AED1).*

Finally, one of the physicians who use Apps in their practice discussed how important it is to consider "digital literacy" and make sure the person advised of using an App has the necessary technology available. They said:

> *"I usually do ask about connectivity and access to Wi-Fi. What kind of devices they have, and [their] familiarity with using devices, if I am recommending Apps as a potential resource. Similarly, if I were asking someone to utilize videos for education or mindfulness or relaxation on YouTube, I would ask about their familiarity with YouTube" (PE).*

Mhealth apps in clinical practice

Without standardized guidelines, a physician's familiarity with technology often correlates with how they incorporate Mhealth Apps into their practice.

> One physician said, *"I haven't used any [Mhealth Apps]. I have heard of some recommendations going back and forth between clinicians around the Apps, but specifically, I have not recommended any" (P).* The other physician, on the other hand, who developed Apps in the past, said, *"I can definitely say I've had some patients who are able to use [Mhealth Apps] and integrate them in their day-to-day and then report back as part of our continued follow-up care" (PE).*

There was a discussion with physicians about the potential for Mhealth Apps to be another therapeutic option for them to use when working with a patient. In addition, the physicians discussed issues related to the appropriateness of when to recommend Apps.

> One physician said, *"I do see a number of young people too now, and they're probably more willing to try Apps than others" (P).* Another physician said, *"There are opportunities to be one part of the toolkit for a clinician, whether it's an in-person type of care and augmenting it or it was being completely virtual. So, I do see that it holds promise in terms of decreasing barriers for waitlists and increasing access" (PE).* This physician also expressed some concerns over the App use, *"The other piece is I do have a worry about is that sometimes we'll get to a point where Apps are thought to be the replacement for other types of*

interventions" (PE). The physician mentioned the use of Apps within a stepped care model of care *"So, let's say if the access to actual therapy is a bit delayed or there is a longer waitlist, it's probably better than nothing to start with an App" (P).*

Finally, in terms of improving Mhealth App use in clinical practice, participants offered helpful advice:

> *"There are a lot of wellness Apps out there, for example, and [we should] make sure that the clinicians know how and when to use them in the treatment algorithm or pathway" (PE). One* of the AET developers said, *"I think patients are comfortable telling us they're using Apps, but we certainly make it part of our business." (AED1).*

The usefulness of the Mhealth apps

> All the participants agreed on the usefulness of the Apps, albeit with some reservations. One participant said, *"I found it very effective to the point where I actually recommend this App to other people" (PLM).* Another participant said, *"I've seen transient benefits that really drop off overtime where the first couple of weeks people are engaged, and then after a while, people have ignored the alerts to log in or to participate" (PE). One* AET developer said, *"I think that as self-help tools, the evidence from the peer-reviewed literature is that they're pretty limited [in usefulness]. They don't harm you, but it's a pretty small effect when used in the context of a clinical relationship" (AED2).* The other AET developer expressed their concerns as *"it's not the problem that people don't want to use something. It's just, what's out there isn't actually what they need or want, or just isn't useful" (AED1).*

Views and opinions on AETs for Mhealth apps

Need for AETs

As discussed, the need for AETs in a fast-paced and lucrative field of mental health provision is essential to help guide users amongst the numerous options, highlight safety, and privacy concerns, and provide the necessary tools for informed decision-making.

> One physician said, *"I think a framework is critical because a checklist would be ideal for clinicians." (PE) One* AET developer emphasized the need for developing AETs by saying, *"It's an important decision of what you're using, and there are risks and benefits. It's different from downloading Candy Crush, even though they're marketed the same, and sometimes look the same." (AED1)* The person with lived experience of a mental health illness said, *"If there are these resources like a list of Apps, I want to know so I can share them with other people" (PLM).* Similarly, another AET developer said, *"Well, no one's been hurt. Well, we don't know that. You may have delayed treatments because of that [if the App was not effective]" (AED2).* This same AET developer also emphasized the need for better policies, *"we'll need to have better policy oversight for that [better regulation of Mhealth Apps]" (AED2).*

Development of AETs

The AET developers provided insight into how the AET should be developed. One AET developer discussed their AET development process in some detail.

> *"We had several iterations of the framework. We presented it at different meetings for several years. We worked with it, with our different patients in our clinics, and we got a feel for what pieces mattered to people and which didn't. Then eventually, we went to the research literature and looked at other frameworks. We looked up all of the research literature, and a little bit of the gray literature around it" (AED1).*

Key considerations included whether the AET has been subjected to evidence-based research, its development was carefully documented and included in published reports, and whether there was stakeholder involvement (and to what degree).

> *"I think that should just be a group of people from all these different backgrounds. You'll have potential developers involved as well, but researchers, clients, subject matter experts, anybody really" (AD).*
>
> *"So, we were at local clubhouses in the community" (AED1).*
>
> *"We are organizing panels of experts. We assembled people who were both scientists, and we consulted people with lived experience as well"* (AED2).

Awareness and use of AETs

Apart from the AET developers and the physician with experience in App use, stakeholders (including the App developer) either reported that they were not aware of the existence of AETs for Mhealth Apps or, if they had, they expressed concern that the AETs largely go unknown to the average App user. Thus, awareness of AETs appears to be a key component for widespread implementation.

> *"No [not aware of an AET]. There's no framework that we're checking off that we've been following per se" (AD). One* physician emphasized the need for Governmental agencies to be involved, *"So, I think there needs to be more collaborative work around it, and possibly the government should play a bigger role in this because they should assume some responsibility in the delivery of care" (P).* The person with lived experience of a mental health illness at first reported no knowledge of AETs upon further inquiry, said, *"If I'm in a place where I want to look for an App and the guideline is super easy, like low engagement, low reading, then yeah, I might be interested to see what are some points that have to be within an App. Or for there to be sort of like*

> *a flag at the beginning. Even within the description, it says that this meets that guideline. Then I'm like,' Great,' I would assume this was good" (PLM).*

Areas for improvement

All interviewees reported that a potential weakness of the AETs was their exclusion of criteria that report on cultural issues and features that personalize the App experience to a user's identity. Most AETs in our review did not include culture, language, ethnicity and race, lifespan, and gender considerations in their selection criteria. One AET developer highlighted the importance of age and language consideration as:

> *"The vast, vast, vast majority of Apps do not ask your age and consent of your parents if they're collecting clinical grade data. And that's a legal problem because those Apps are collecting things with that. So, you couldn't do that with a website. So, there are rules for that, so we made special notice of how you collect data for youth and the consent process. But other than that, all of the other criteria are age-independent" (AED2).*

Similarly, it was highlighted how vital disclosure of conflict of interest and financial disclosure by AET developers is to ensure that AETs are not promoting one App or another:

> *"[An AET] needs to be explicit on everyone's in terms of conflicts of interest, right? Because people who may be recommending Apps, especially if they were developers of the App- Or have a financial interest around the advisory boards and things like that. Not everyone discloses their conflicts of interest"* (AED2).

Finally, it was pointed out that most AETs were not developed using rigorous methodology. As a result, none of the AETs have been formally evaluated. Similarly, most AETs do not offer advice on how to use their selection or evaluation criteria:

> *"The framework [development process] is not rigorous. It has to be measurable, and it has to be measurable in a reliable way. You can't just use any old survey of questions. You should be using something that's been validated" (AED2).*

Implementation barriers

Mental health apps

Despite the promise that Mhealth App technology holds, numerous stakeholders expressed concern over the barriers to users before widespread implementation is possible. These barriers include inequities in access to technology (i.e., the digital divide), skills to utilize technology (i.e., digital literacy) thoroughly, and cost barriers.

> Like this participant said, *"So, technology readiness is a problem, and training and support" (AED2).* One AET developer discussed the need to improve digital literacy, *"I think the best way really to link digital literacy with App evaluation is that they kind of go together, if you're looking to improve mental healthcare" (AED1).* One of the physicians said, *"I do think that digital equity is an important piece about how we ensure that Apps are culturally adapted, responsive, and tailored for specific patient populations? (PE)".* They further emphasized the need for equity in this area, *"It's unrealistic to think that all Apps will be able to be designed for all populations. We did this in one of our libraries, our App libraries, to flag whether there were Apps tailored for indigenous or black patient populations given the need for cultural sensitivity and being adaptable for those patient populations. There were not many (Apps), as you would imagine" (PE).*

One AET developer offered insights on implementing the AETs in clinical work and suggested possible changes in health systems to improve the use of Mhealth Apps.

> *"So social workers usually are asked to do multiple things, but now we can add them to be clinical support, digital interventions, right? And so, I think we need to look at roles and responsibilities, and who needs to be involved in the technical aspect, and what training and support we give to them. So, I think a lot of people are overwhelmed, and the integration can't happen without some planning and additional support" (AED2).*

The person with lived experience of a mental health illness expressed their concern regarding the cost of the Apps and their views regarding the authenticity of the App builder.

> *"First of all, it's just a financial barrier. I wouldn't want that. Then I would think about yeah, it is a bigger privatized business kind of thing. I would like it to come from a mental health commission or a hospital. I wouldn't want it to come from a company. I mean, those are companies, but you know what I mean" (PLM).*

The physician educator described their concerns regarding privacy, security, and risk awareness as a potential barrier to implementation:

> *"So, I think more and more we recognize the importance of digital safety and privacy, right? That's a huge key. I know there's lots of research coming out about how a lot of these Apps do not disclose their privacy regulations and processes explicitly, either in the App itself or on the website you're downloading from. It's so important to inform patients about that. So, I do think people using their information secondarily for other sources is a risk and also might be a deterrent for some clinicians, including myself" (PE).*

The AETs for mental health apps

There was full agreement amongst our participants about the necessity for AETs to assess quality for Apps, but numerous barriers were highlighted about the widespread adoption of AETs. Interviewees either were not aware that AETs existed, or individuals with experience in the field (i.e., AET developers) expressed their concern that the AETs were not

visible or widely disseminated by the individuals who most need it.

> *"One, to do it properly [implement a framework], you need time and train people on how to do that. And the question is, where do we, [or] how do we find the money to help train people to do that? If you're not trained in how to do these assessments properly, you're not going to get a consistent or reliable result" (AED2).* Another participant emphasized the need to improve digital literacy to facilitate the implementation of the AETs, "*So, I think the best way really to link digital literacy with App evaluation is that they go together if you're looking to improve mental healthcare" (PE).*

It was also discussed that the language used, considerations implemented from a user's perspective, and the format in which the AET is disseminated were significant factors that affected the degree to which Users or clinicians could widely adopt AETs.

> *"But if I'm in a place where I just want help, and just like a quick response to find something, ideally it works, and let's just go with that. I probably wouldn't do this [review an AET]. I probably wouldn't take the time to do the research" (PLM).*

Difficulties in the evaluation of Mhealth apps

Numerous stakeholders focused on the deficiencies of the present research on Mhealth App effectiveness, raising questions of the ability to control variables of interest in long-term studies conducted outside of the research lab and the competing interests of marketing and scientific motives. Of particular interest were the comments that raised concerns about the rigor and design of studies that tout the Mhealth Apps' effectiveness. For example, results are often reported from small and quickly completed feasibility studies instead of large-scale randomized controlled trials (though there are difficulties in conducting these).

> *"It seems like a piecemeal approach. The clinicians are on one side, and the App developers are on the other side. They seem to have a different focus [on what the user wants]" (P). "Also, a lot of them [evaluations] have small sample sizes. We found that there are many Apps with limited evaluation, so there's a lot of methodology problems with it. If the App is used in conjunction with face-to-face services, you need to know to what extent the face-to-face services contributed to the outcome vs. the App" (AED2).*

Some of the participants highlighted the lack of an agreed definition for the effectiveness of the Apps.

> *"People define 'effectiveness' vastly different, or they don't define it at all, which makes it even more challenging to decide what they're recommending. I think problem number one is that there isn't an agreement on what is considered to be effective" (AED2).*

Evaluation of AETs (problems)

As mentioned earlier, none of the AETs have been evaluated. One of the interviewees with extensive experience in assessing AETs highlighted the potential for the risk involved in using AETs that do not have a consistent and rigorous methodology in their design, implementation, and testing. A set of guidelines for the evaluation of AETs and aid in the development of AETs specific to the health field is a goal.

> *"I think there are a plethora of frameworks that aren't scientifically based, and that causes a huge problem because some of them can give an inconsistent level of rating that makes it look like an App works when it hasn't been scientifically evaluated for effectiveness" (AE2).*

Future directions

Key informants agreed that the field was still in its infancy, with much work to be done (as expected with the technology's novelty). This included the desire for more rigorous development of AETs and a broad re-conceptualization of critical factors to be evaluated and how they should be presented to users and clinicians in an accessible (and innovative) way and who should be involved in that process.

> *"I think there's a lot of room for improvement [in the development and evaluation of Mhealth Apps]" (P). One* AET developer said, "I mean, it's a strange evolving space" (AED1).

Further, the clear identification of competing interests of those embarking on App evaluation, and the development of AETs, was of the utmost importance to all key informants. There was agreement that the distinction between for-profit and non-profit was essential in this domain. The need to be transparent and clear to App users and health providers. It may require further steps of regulation.

> "*So not only do we need to use [an AET], but we need to use one that is evidence-based, scientifically-based, that's transparently evaluated without conflicts of interest, and there has to be oversight of how we're implementing the framework, and then how people are actually using the Apps, and based on those evaluations, circle back to, maybe we need to recommend other Apps, or maybe we need to implement them differently" (AED2).* Or, as the other AET developer said, *"I mean, eventually there's going to have to be enforceable standards for these" (AED1).*

Special attention could be paid to the AET developers and researchers who have spent a lot of time considering development goals and stress-testing the AET's implementation and effectiveness. Their recommendation of how the field can ideally advance is illuminating.

> *"So, I think we need some advocacy by groups... and we need transparency in science. [Because we have] a vaccine that gets put in our arm that has been transparently and scientifically evaluated. And so, if we expect that of a vaccine if we expect that of a drug, we should expect that with [these] interventions too" (AED2).*

Discussion

As far as we know, this is the first qualitative study to explore stakeholders' views and opinions on existing AETs. The overall purpose of the AET is to guide end-users on how to choose a Mhealth App. App developers, AET developers, and clinicians can have different ideas on selecting Apps. Overall, many stakeholders, including people who use Mhealth Apps, are unaware of AETs for Mhealth apps. Even though consumers consider user ratings when selecting an App, they do not portray an accurate image of App suitability, assuming they are not reinforced by empirical evidence (8). Thus, another way for consumers and clinicians to choose an App is to use an App review platform (8).

According to Schueller and Wykes (29), four principles should be used when the consumer selects an application to download called the Transparency for Trust (T4T) principles. These include privacy and data security, development characteristics, feasibility data, and benefits (29). It should be the responsibility of the App store to provide the information from these principles for a health App (29). The majority of respondents (66%) to the online survey stated that ratings and reviews on the App Store and Play Store are the main factors they take into account when choosing an app.

Participants in our study emphasized the need for equity, diversity, and inclusion for the AETs. Most participants emphasized the need for further improvements to Mhealth Apps to address areas of concern such as cultural sensitivity. Both Apps and AETs appear to pay little consideration to cultural, gender, language, and lifespan issues. Since the COVID-19 pandemic and mainstream recognition of systemic racism, greater attention is being paid to digital health and its capabilities in increasing access to and standards of behavioral health care (30). Regardless, this greater dependency on digital health during the pandemic has continued to create more considerable health disparities in racial and ethnic minority groups, in turn amplifying the digital divide. This is an issue for racial and ethnic minority groups that already suffer health disparities and a greater reliance on digital health technologies, increasing the digital divide (30). In terms of AETs, Zelmer et al. (31), highlight that organizations or individuals recommend Apps based on various factors; however, it is uncertain if these factors are generalizable to different groups based on culture, gender, and language (31). According to leaders within the Computing Community Consortium and Society for Behavioral Medicine from multidisciplinary fields, they have agreed that reducing inequality would mean that these minority groups are involved "at all stages of intervention design, implementation, and evaluation" (32).

Numerous stakeholders, including a person with lived experience of a mental health illness, were concerned about privacy and safety concerns around App privacy and invasive data collection. This is a concern because most health Apps gather a lot of information on personal data, which affects health, so it is imperative to ensure safety, validity, reliability, privacy, and security. The Organization for Economic Co-operation and Development (OECD) developed a report in 2017 that stated the use of poor quality and non-medical health Apps brings about many ethical, legal, and governance issues. Thus, there needs to be an international agreement on basic standards for quality assurance and an easy source for App developers and users to follow (33). Analysis of mHealth Apps privacy is usually based on the user interface, communications privacy, and the privacy policy. The guidelines for assessment in existing AETs are less objective and heterogeneous, particularly for user interface and privacy policies. Hence, a more comprehensive evaluation needs to be created for these policies to produce more accurate results after using these assessments (34). Torous et al. (35), suggest the following strategies to improve data safety and privacy: data use, storage and sharing policies that are transparent to users of the App, standards agreed upon for data usage, storage and sharing, end-user awareness of data being shared with external partners, and the end-user should be given the option to stop sharing their information (35).

The use of Mhealth Apps in clinical practice varies among clinicians depending on their background and interest. Interviewed physicians described problems related to access to technology and digital literacy. Similarly, functionality (83%), and ease of use (77%), were the two biggest considerations that online survey respondents indicated they looked for in an Mhealth App. According to Nouri et al. (36), populations with limited digital literacy are less likely to use mobile Apps. Many of these groups are vulnerable or minority populations, that regardless of having smartphones, still struggle with text- messaging (36). Therefore having a phone and using it daily does not mean someone is able to use basic smartphone functions use such as texting. Digital health literacy is the skill to evaluate health information from varying electronic sources and use that information toward resolving a health-related problem (37). Accordingly, prior to mHealths' most significant hurdle is digital health literacy and requires a combination of both general and health literacy (37). In the paper by Smith and Magnani (37), a Digital Universal precautions for eHealth literature health care organization was generated to improve the accessibility of eHealth services for everyone (37). The safeguards included: creating an interdisciplinary team including programmers, designers, and patients, creating user-friendly and convenient digital media resources that are actionable and evidence-based, the delivery of media through video or audio to increase communication for those with limited literacy, and interactive services where patients can tailor information to their needs. Although, in the case when individuals do not have access to the internet, organizations should supply devices or the means to the technology (37).

The existing research methods may not fully consider complexities in evaluations of Mhealth Apps. Engagement with Mhealth Apps is a significant issue. The lifespan of most Apps is very short. Furthermore, there are many mhealth Apps available to consumers. However, only a few meet the requirements to be incorporated into a healthcare system. Considering App development and change occurs very quickly, the complicated and prolonged clinical studies that determined the effectiveness of just one App cannot keep up with the ever-changing App market (38).

Moreover, there is insufficient agreement on the minimum methodological guidelines that should be used for App evaluation which has caused a more intensive evaluation that includes mHealth randomized controlled trials (RCTs) being performed in countries (39). Technology is fast-paced, and an App platform being evaluated using RCT can become outdated during the clinical trial (39). Other factors that affect App evaluation include incorporating an interdisciplinary team, elaborate sociotechnical aspects that the mHealth success relies on, and external factors such as financial, human, and time resources to perform these evaluations (39).

While several AETs are available for end-users, not many of our stakeholders were aware of AETs. Implementation of an AET appears to be a significant barrier. The stakeholders emphasized the need for advocacy and engagement of health professionals in the implementation process for AETs. This is evident in the online survey, where 68% of participants said they would trust a hospital the most to create a mental health app. 84% of respondents would prefer a health expert to provide guidance on Mhealth Apps, and 70% would like health care providers to design an AET. Aside from health professionals, individuals outside the medical field have not had the chance to voice their opinions on these assessments of health aids even though they know the benefits of mHealth. Along with technology, developers investigating the possibility of "ever-present self-management systems," should have a mutually beneficial relationship with the medical system, so evaluation frameworks are safer for end-users, transparent, and trustworthy. These findings are very similar to those in Van Daele (40), which highlights all stakeholders involvement is a necessity. As such, health authorities, patients, and mHealth developers need to be actively involved during the process of creating evaluations for mHealth (41). In general, all stakeholders involvement is a necessity to disseminate superior health care and digitally delivering mental health (40).

Limitations and future directions

The generalizability of the findings from this study may be limited due to having a limited number of participants and individuals with lived or living experiences of mental health illness and a small sample size overall for the online survey. In relation, there were considerable time and financial restrictions. We used convenient sampling that further poses limitations on generalizability of this study, for example no psychologists or nurses were included in this study. Another limitation was the general lack of agreement within the field surrounding terminology and definitions of assessment criteria that may have led to misinterpretations for qualitative purposes, even though expert opinion was sought.

More research is required to understand health Apps for physical and mental health, the buying tendencies of people who use Mhealth Apps, the perspectives of healthcare professionals, and the impact of digital literacy and access to technology. AETs cannot be more functional until more research is done on end users' requirements, perceptions, and expectations. Research funding streams specific to Mhealth Apps will be a wise investment to assess the quality of mental health care apps. Finally, understanding the perspectives of App developers and engaging them to regulate health Apps is critical.

Conclusion

This qualitative study explored stakeholders' views of AETs (Assessment and Evaluation Tools) for Mental health Applications (Mhealth Apps). Sparse information or advice is available from authentic sources on "how to choose a Mhealth App". Many people are unaware of existing guidelines for choosing Apps, developed mainly by academics interested in this area. The problem is further compounded by the fact that very little evidence is available for the effectiveness of the Apps, and the existing methods in mental health research do not provide clear guidance on developing and testing Mhealth Apps. Stakeholders agreed that Apps could significantly impact mental health if evaluated adequately through a rigorous methodology and implemented effectively. The stakeholder commented on a need for clear evaluation guidelines for end-users need to be able to trust the reliability of App evaluations. The primary barrier described by the stakeholders was the *implementation* of apps in healthcare delivery services. There is a clear need for more research in this area.

We quantified some of the themes emerging from the literature review and the qualitative interviews using an online survey that mainly focused on the end-users. This survey confirmed that for Mhealth App users, the primary source of information remains app distributors such as Google's Play Store or Apple's App Store since the app users had limited knowledge of the AETs. The participants considered functionality, ease of use, and cost as the three primary reasons to choose an app and were less concerned about evidence from research, privacy and security (factors that AETs and the current regulations heavily rely on). The primary focus of Mhealth app users, and of Mhealth app developers, appears to be on the utility provided to the user. Finally, the app users considered health professionals to be their overwhelming choice to guide them in selecting an app. It is yet to be seen whether health care professionals and health care organizations around the world are ready to step to the forefront.

Data availability statement

The datasets presented in this article are not readily available because the data belongs to The Centre for Addiction and Mental Health. Requests to access the datasets should be directed to farooq.naeem@camh.ca.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

WK, CT, and FN were actively involved in conducting the semi-structured interviews for the study and in the completion of the analysis of the interviews. WK wrote the first draft of the manuscript with the assistance of FN. BJ wrote the second draft of the manuscript with the assistance of WK and FN. All authors reviewed and edited the manuscript and approved the final manuscript for submission to the journal.

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KK, SW, and MAb were employed by Mental Health Commission of Canada.

The remaining 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.2023.1251050/full#supplementary-material

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Does WeChat use intensity influence Chinese college students' mental health through social use of WeChat, entertainment use of WeChat, and bonding social capital?

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Background: Previous research notes that the usage of WeChat is significantly related to individuals' mental health, but the underlying mechanism is still not completely discovered. The present study aimed to explore the sequential mediating roles of WeChat use motivations and bonding social capital on the effects of WeChat use intensity on mental health in Chinese college students.

Method: The present study adopted an online survey with a total of 487 Chinese college students. Correlation analysis and serial mediation analysis were measured by process regarding the hypothesis.

Results: The study presented findings indicating that WeChat use intensity had both direct and indirect impacts on the levels of life satisfaction and loneliness experienced by college students in China. Specifically, the utilization of WeChat for social motivation and entertainment motivation was found to have a suppressive effect on the relationship between the intensity of WeChat usage and individuals' life satisfaction. The association between the intensity of WeChat usage and mental health outcomes (life satisfaction and loneliness) was found to be mediated by bonding social capital. Furthermore, the association between the intensity of WeChat usage and mental health was found to be mediated by the sequential mediation effects of using WeChat for social motivation and bonding social capital, as well as the sequential mediation effects of using WeChat for entertainment motivation and bonding social capital.

Conclusion: Our findings provide implications for policymakers and social workers regarding renovating the perceptions of the relationships between WeChat use intensity and overall mental health. Specifically, practical online activities and services of SNSs are recommended to be designed for meeting social and recreational gratifications and boosting bonding social capital, which in turn promotes psychological wellbeing.

KEYWORDS

WeChat usage intensity, WeChat use motivations, bonding social capital, mental health, Chinese college students

1 Introduction

WeChat (微信; Wexin) is a highly popular social networking site (SNS) that was launched by Tencent Technology in January 2011 (1). Due to the blocking of popular social media platforms such as Facebook, YouTube, and Twitter in China, marketers have turned to WeChat as a viable means of direct communication with their Chinese target audience (2, 3). WeChat is a versatile program that extends beyond the conventional features of social networking services (4). WeChat, a major messaging platform, shares similarities with WhatsApp. It was originally created to enhance the accessibility and efficiency of online communication. WeChat offers several features such as text and voice messaging, instant message notifications, and video/voice calling capabilities (5). To cater to the diverse needs of its users, the WeChat team has devised a range of social and entertainment services. These include Moments, which allows users to share photos and videos; WeChat Group, which enables group conversations; Shake, which facilitates the discovery of other users currently engaged in the Shake feature; People Nearby, which enables users to locate others in close proximity; and Subscriptions, which provides users with access to subscribed articles (6). According to Liao et al. (7), WeChat has more than 1.2 billion monthly active users who have accessed WeChat through their smart mobile phones and computers since 2021. Given the increasing prominence of WeChat in everyday life, recent scholarly investigations have focused on examining the influence of WeChat usage on individuals' social networks and mental wellbeing (6, 8). Several studies have demonstrated a positive correlation between the intensity of WeChat usage and the social and psychological consequences for individuals (9–11). In line with concerns expressed by scholars on the negative consequences associated with Facebook and other global social networking sites (SNSs), some researchers express apprehension about the adverse impacts attributed to WeChat. Specifically, various studies have focused on the emergence of technology-related disorders, such as addiction to mobile phones (12), Internet usage (13), computer and video games (14), negative body image (15), and mental disorders (2, 16). According to Williams (17) assertion, how researchers see and define the medium can influence the development of cyber-pessimism and cyber-optimism. The continuous debate between cyber-pessimists and cyber-optimists is notwithstanding, and there exists a subject of more scholarly significance: the examination of how WeChat, specifically, exerts a positive influence on the physical and mental wellbeing of its users. This study sought to examine the underlying mechanisms between the usage of WeChat and mental health, in line with mutual concerns in this area.

To the best of our knowledge, previous studies only identified the isolated mediation role of WeChat use motivation or social capital, but there is no research systematically involving the potential mediators regarding examining the mechanisms between WeChat use intensity and mental health. Pang (18) designed the study to reveal the full mediation effect of social capital on the effect of WeChat use intensity on the subjective wellbeing of Chinese international students in Germany, but WeChat use motivation was not involved in his study. In addition, the research is aimed at foreign students in China. Due to cultural differences, the impact of WeChat use on the mental health of college students in China may be inconsistent. In contrast, Wen et al. (19) suggested that WeChat use motivation significantly mediates the association between WeChat use intensity and mental health. However, they did not investigate the roles of bonding social capital. To fill the current gap, the current research focused on exploring the underlying associations between WeChat use intensity and mental health, by introducing WeChat use motivation and bonding social capital as sequential mediators simultaneously. Regarding WeChat use motivation, we simultaneously consider the social use of WeChat and the entertainment use of WeChat. We also simultaneously consider two main types of mental health: life satisfaction and loneliness. Meanwhile, our study may expand the framework of Pang and Wang (20) into two important aspects. First, this is the first research that integratively and systematically examines the relationship between WeChat use intensity, motivations, bonding social capital, and mental health. By investigating the mediating influence of WeChat use motivation and bonding social capital, this research offers a more thorough comprehension of the mechanisms underlying WeChat use intensity in Chinese college students' mental health. Second, from the perspective of self-determination theory and the emotional motivation theory, this article also assists college students' proper and scientific use of new media which may exert positive effects on their psychological wellbeing. That is to say, these findings may guide the development of prevention and intervention strategies to protect college students from improper WeChat use. The theoretical models of this study are illustrated in Figure 1.

2 Literature review and research hypotheses

2.1 The mediating roles of WeChat use motivation

The evaluation of WeChat usage intensity frequently centers on the behavioral aspect, especially analyzing individuals' daily usage patterns. This assessment incorporates multiple indications, such as the quantity of WeChat friends, the duration of WeChat usage, and the frequency of platform access. According to the findings by Wen et al. (19), the mere utilization of WeChat does not intrinsically elicit emotions of contentment or unhappiness among individuals. However, the users' ultimate emotional experiences predominantly arise from the reasoning and methodology applied in employing the platform. Motivation exerts a substantial impact on persons' behavior and their entire emotional experiences. The use and gratification theory [UGT; (21)] has become increasingly popular in the study of motives within the media domain, particularly in relation to social networking sites (SNSs) (22–24). According to Blumler and Katz (21), the UGT framework suggests that individuals engage in an active process of selecting social media sites to meet their specific needs. According to Leung and Wei (25), the anticipation of continuing can be influenced by several forms of motives, which can be predicted based on patterns of usage. Through the implementation of the Unified Theory of Acceptance and Use of Technology (UGT), researchers can systematically

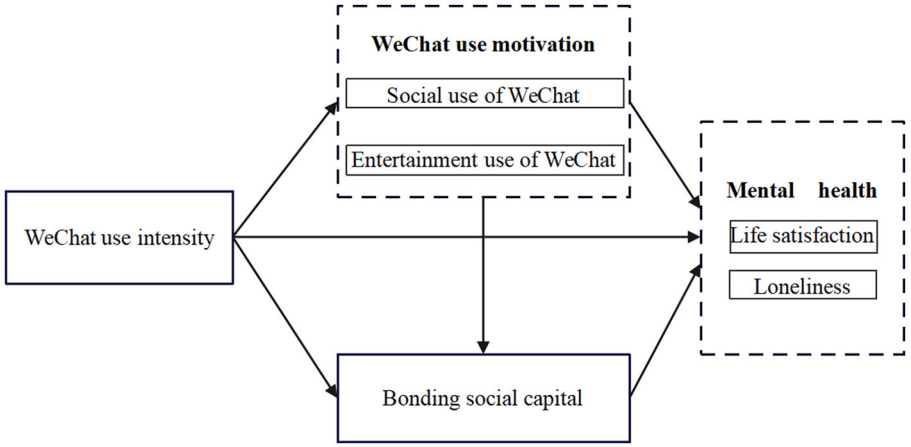

FIGURE 1
Hypothesized model of the impact of WeChat use intensity on mental health among college students in China: WeChat use motivations and bonding social capital as mediators. Age, gender, and education level as control variables.

assess the extent to which social networking site (SNS) usage contributes to the facilitation of incentives that are specific to SNS platforms. WeChat is a versatile application that offers a range of routine services. It has gained recognition as a highly user-friendly social networking site (SNS). WeChat is committed to developing localized functions, such as WeChat Moments, WeChat Payment, and online purchases, which are not available on other Chinese and international SNS platforms. WeChat's competitive advantage in the Chinese social networking sites (SNSs) industry can be attributed to its exclusive offerings, which encompass a diverse range of features not readily available on alternative platforms. The voluntary orientations of users contribute to the increased consumption of specific media (26) and the gratifications derived from using particular services. Consequently, individuals who have experienced satisfaction through WeChat are inclined to develop a reliance on the platform, regularly seeking and obtaining gratification exclusively through WeChat. Motivational factors mostly consist of gratifications. Moreover, the empirical research conducted on WeChat aligns with the principles and guidelines of UGT. According to Wen et al. (19), the level of intensity in using WeChat can serve as an indicator of several motivations for the use of the platform. According to the study conducted by Montag et al. (27), it was discovered that regular use of WeChat has the potential to influence particular motives. These motivations subsequently prompt individuals to utilize WeChat as a means of fulfilling their psychological needs. It can be argued that the cultivation of motivation in the use of WeChat is possible, as frequent usage does not necessarily lead to increased boredom among users. Instead, it has the potential to strengthen a user's motivation to continue using the platform and elicit good emotions. According to self-determination theory, intrinsic motivation ensures the activity is performed for its enjoyment rather than for external outcomes and is associated with a multitude of positive outcomes (28). Intrinsic motivation flourishes in contexts where the three psychological needs, competence, autonomy, and relatedness, are satisfied (29).

WeChat use motivation may act as a mediator between WeChat use intensity and mental health. Numerous scholars believe that SNSs are neither good nor bad, but the types of utilization matter (30, 31). WeChat use itself does not bring happiness or unhappiness to people, while the user's ultimate emotional experience mainly comes from the reason and method of use. Use motivation plays an important role in use behaviors and the overall emotional experience (19). In the era of social media, several scholars have applied the UandG approach to discover the psychological motivations for using social networking sites. The previous research identified the important motivations underlying the use of the Internet including information, convenience, entertainment, and social interaction (32). Based on the self-determination theory, Ryan and Connell defined four types of reasons for behaviors: external reasons (external authority or fear of punishment), introjected reasons (internal, esteem-based pressure, e.g., shame), identification reasons (values or goals), and intrinsic reasons (enjoyment or fun inherent to the behaviors) (33). Guo et al. (34) deprived "social-informational function" and "entertaining-recreational function" from Weiser's (35) Internet Use Function Scale to assess WeChat-oriented motivations. Social use of SNS and entertainment use of SNS are two prominent motivators that have been examined by many studies (36–39). Therefore, this study focuses on investigating social use motivation and entertainment use motivation. Social use of WeChat denotes individuals use WeChat for aims of interpersonal communication, social interaction, and social presence, while entertainment use of WeChat focuses on the motivations of enjoyment and passing the time (34, 40).

A majority of SNS studies report that social and entertainment motivations exert significant effects on subjective wellbeing (18, 41). Based on self-determination theory, SNS media can provide specific satisfaction for individual users. The social utilization of social media platforms has been found to have the potential to enhance social support, reinforce an individual's connection to the physical world, and facilitate self-expression and the acquisition

of social support (42). Furthermore, Guo et al. (34) found that entertainment-recreational functions of SNS could contribute to the aggravation of loneliness, which is in line with early SNS research that entertainment use of technological devices (e.g., digital games) tends to cause addictive behaviors and mental illnesses (43). In contrast, Poppelaars et al. (44) found that a video game, being promoted as simply fun, likely appeals to a person's intrinsic values making it less likely to provoke reactance. Wen et al. (19) found that intrinsic use motivation (e.g., use of WeChat for fun) was the mediator between the use intensity and subjective wellbeing, while the other three types of motivation (external, introjection, and identification) cannot predict subjective wellbeing significantly. According to Wang et al. (45), the social-interactive use was positively related to college students' subjective wellbeing, but the entertainment was not. The ambiguous outcomes may be attributed to inconsistent measurements for entertainment motivation, in particular, the definition of "entertainment." For example, Li et al. (46) measured "entertainment" from three dimensions, namely, fantasy, escapism, and enjoyment, while Xu et al. (47) measured "entertainment use" from affection and leisure. To avoid bias caused by inconsistent measurements, the present study adopted Guo et al. (34) methods of assessing social and entertainment motivations. Therefore, this study recommends the hypothesis as follows:

Hypothesis 1a: Social usage mediates the effect of WeChat use intensity on life satisfaction.

Hypothesis 1b: Social usage mediates the effect of WeChat use intensity on loneliness.

Hypothesis 2a: Entertainment usage mediates the effect of WeChat use intensity and life satisfaction.

Hypothesis 2b: Entertainment usage mediates the effect of WeChat use intensity and loneliness.

2.2 The mediating role of bonding social capital

Bonding social capital could potentially serve as a mediator in the relationship between the level of WeChat usage and an individual's mental wellbeing. Social capital can be described as a resource within an ecological context, encompassing elements such as value, connection, and trust. This resource is found within the social networks of individuals, with a particular emphasis on social networking sites (SNSs) (48, 49). In his seminal study, Putnam (50) initially introduced the notion of bonded social capital. According to Putnam (50) conceptual framework, bonding social capital is cultivated through the establishment of close-knit networks, wherein individuals can both offer and receive emotional support within their social connections. According to Chen and Li (51), social media possesses the capacity to bring about changes in individuals' wellbeing through major mediators, rather than exerting a direct influence, such as the formation of bonded social capital. WeChat functions as a communication platform that primarily supports interactions among individuals and small groups. The primary objective of this platform is to enhance interpersonal connections and cultivate a sense of confidence among individuals who are already familiar with one another, such as relatives and coworkers (52). Furthermore, the establishment of stronger interpersonal ties can be facilitated by participating in intimate self-disclosure, which involves the communication of private and in-depth information at a personal level. This concept aligns with the social penetration theory put forth by Altman and Taylor (53). Hence, it is apparent that engaging in individualized conversations on WeChat yields advantages in the development of social capital, which in turn facilitates the establishment of social bonds. Numerous research studies have been conducted to investigate the impact of social networking site (SNS) usage on the dynamics of bonding social capital, as evidenced by the works of Burke et al. (54), Kwon et al. (55), Papacharissi and Mendelson (56), and Raacke and Bonds-Raacke (57). Valenzuela et al. (41) provide a more detailed elucidation. According to previous research conducted by Alsaggaf (58), McQuail (59), and Valenzuela et al. (41), it has been proposed that the utilization of social networking sites (SNSs) has the potential to satisfy individuals' desires for social integration and personal identity presence. These factors have been highlighted as important indicators of social capital at the individual level. According to Pang (18), research on WeChat usage has identified a significant correlation between the intensity of WeChat use and the development of bonding social capital. Drawing upon existing scholarly works, the current research posited a hypothesis on the substantial and positive correlation between the level of engagement with WeChat and the development of bonding social capital.

Since the year 2001, mental health has been recognized and acknowledged as a significant worldwide burden of disease by the WHO. Scholars have placed significant emphasis on the importance of bonding social capital in mitigating psychological diseases. This emphasis is driven by the objectives of fostering trust, safeguarding distinct social identities, and facilitating reciprocal interactions among individuals (50, 60). Extensive scholarly inquiry, both theoretical and empirical in nature, has been dedicated to exploring the association between bonding social capital and mental health or subjective wellbeing (61–64).

The increasing recognition of the importance of social capital has led to a surge of research investigating the impact of bonding social capital on individuals' levels of life satisfaction and feelings of loneliness. Diener et al. (65) suggest that self-rated life satisfaction serves as an indicator of an individual's overall happiness with various life occurrences. The presence of low life satisfaction is associated with an increased likelihood of experiencing subjective wellbeing concerns, as evidenced by studies conducted by Fergusson et al. (66) and Swami et al. (67). According to the findings of Elgar et al. (60), which were derived from a sample of 69,725 adults across 50 nations, it was proposed that there exists a direct and indirect relationship between bonding social capital and the health and life satisfaction of individuals. The findings of two research conducted by Pang (18, 68) indicate that bonding social capital, formed through the WeChat social network, is a significant predictor of life satisfaction. According to Weiss (69), the construct of loneliness can be characterized as a state of social and emotional isolation, rather than being indicative of personal inadequacy. Loneliness has been found to exacerbate the negative effects associated with low subjective wellbeing, as indicated by pertinent research (70). In their study, Burke et al. (71) analyzed

self-rated Facebook data from individuals of several nationalities. Their findings indicate a strong and inverse relationship between bonding social capital and feelings of loneliness. Nyqvist et al. (72) discovered that low trust, which is a fundamental element of bonding social capital, serves as a strong indicator of feelings of loneliness. According to Pang (18), research on WeChat usage indicates that bonding social capital is a significant factor that has an inverse relationship with feelings of loneliness. Consistent with other research, the present study posited that bonding social capital is a significant predictor of both life happiness and loneliness. Therefore, the essay presents the following assumptions:

Hypothesis 3a: Bonding social capital mediates the effect of WeChat use intensity and life satisfaction.

Hypothesis 3b: Bonding social capital mediates the effect of WeChat use intensity and loneliness.

2.3 The relationship between WeChat use motivations and bonding social capital

Previous studies have conducted empirical studies on Social Networking Sites (SNS), specifically focusing on platforms such as Facebook. These studies have identified that incentives related to social interaction and amusement might serve as predictors for the accumulation of social capital (55, 73). According to Procentese et al. (42), the utilization of social media platforms has been found to enhance social support, foster interpersonal connections in the physical realm, and facilitate self-expression and social support. Pang (9) asserts that the cultivation of strong connections via social media platforms has the potential to enhance the significance of international students and augment their coping mechanisms, namely in terms of social support and social capital. According to the findings of Jin and Zhang (74) study, various aspects of WeChat usage, such as the number of China friends on WeChat, information sharing, social interaction, and WeChat dependence, have a positive correlation with social adaptation. Additionally, qualitative research indicates that the social network formed through WeChat contributes to the improvement of individuals' social skills, alleviation of loneliness, and development of a new cultural identity. Pang (18, 68) conducted a pair of interconnected studies, which demonstrated a substantial positive correlation between the duration of WeChat usage and the extent of one's WeChat network with increased levels of bonding social capital. Hence, drawing upon the UGT and existing empirical studies, it is reasonable to posit that the motivation to use WeChat serves as a mediating factor in the relationship between the intensity of WeChat usage and the formation of social capital. Hence, this analysis posits the subsequent assumptions:

Hypothesis 4a: WeChat use intensity exerts indirect effects on life satisfaction through the social use of WeChat and bonding social capital.

Hypothesis 4b: WeChat use intensity exerts indirect effects on loneliness through the social use of WeChat and bonding social capital.

Hypothesis 5a: WeChat use intensity exerts indirect effects on life satisfaction through the entertainment use of WeChat and bonding social capital.

Hypothesis 5b: WeChat use intensity exerts an indirect effect on loneliness through the entertainment use of WeChat and bonding social capital.

3 Methods

3.1 Data collection and participants

In this section, we will discuss the methods used for data collection and provide information about the participants included in the study. The study was conducted between May and June 2023, employing a multi-stage cluster random sampling technique. Initially, a random selection process is employed to designate four districts within the city of Nanjing, located in China. Subsequently, a university is selected at random within each district. In each educational institution, a single class is randomly selected from a specific major, spanning from the freshman through senior levels. The survey sample for this study comprises all students within each specified class. The researchers acquired consent letters from the subjects. A total of 501 questionnaires were collected for this study, facilitated by class counselors using an online data-collecting platform called SOJUMP (http://www.sojump.com). SOJUMP is a professional and extensively utilized online survey platform in China, boasting a vast membership base of millions of registered individuals around the nation (9). Furthermore, several studies (6) have utilized SOJUMP to investigate individuals' WeChat usage patterns and behaviors. The survey approach was used due to its suitability for the current study, which focuses on examining the potential impact of WeChat usage intensity on individuals' mental wellbeing within mobile social networking service contexts. Moreover, employing an online survey is the most economically viable and temporally expedient approach for gathering data from a substantial cohort of individuals. After eliminating surveys that were deemed invalid due to frequent responses, contradictory positive and negative alternatives, completion times of <120 s, and missing or erroneous information, a total of 487 valid questionnaires were received, resulting in an effective response rate of 97.2%. The sample consists of 246 individuals who identify as men and 241 individuals who identify as women. The mean age of the sample is 20.09 years, with a standard deviation of 1.42. The student population consists of 159 first-year students, 110 second-year students, 117 third-year students, and 101 fourth-year students. Table 1 presents further demographic and descriptive data pertaining to college students.

3.2 Measures

3.2.1 WeChat use intensity

WeChat use intensity was assessed using a three-dimensional framework published by Wen et al. (19), with minor modifications. The following information was collected from the participants: (1) how long has it been since the participants started using WeChat (1 = <6 months, 2 = 6–12 months, 3 = 12–36 months, 4 = longer than 36 months); (2) how long does it take for the participants to use WeChat every day (1 = <0.5 h, 2 = about

TABLE 1 Descriptive statistics for the participants ($N = 487$).

Variables	Distribution (*N*)	Percentage (%)
Age	487 (M = 20.09)	100 (SD = 1.42)
Gender		
Male	246	50.5
Female	241	49.5
Education level		
Freshman	159	32.6
Sophomore	110	22.6
Junior	117	24.0
Senior	101	20.7
Friend number		
<50	56	11.5
50–99	108	22.2
100–299	189	38.8
300–499	78	16.0
500–999	35	7.2
≥1000	21	4.3
Duration		
<6 months	11	2.3
6 months−1 year	46	9.4
1–3 years	96	19.7
>3 years	334	68.6
Time every day		
<0.5 h	36	7.4
0.5–1 h	90	18.5
1–2 h	120	24.6
2–3 h	96	19.7
>3 h	145	29.8

0.5 to 1 h, 3 = about 1 to 2 h, 4 = about 2 to 3 h, and 5 = longer than 3 h); (3) the number of WeChat friends (1 = <50, 2 = 50–99, 3 = 100–299, 4 = 300–499, 5 = 500–999, 6 = more than 1000). The researchers employed principal component analysis and factor rotation techniques to examine the duration and timing of participants' usage of the WeChat platform. The values were ultimately standardized to a scale of 0–100, resulting in the creation of the variable representing the intensity of WeChat usage. The Cronbach's alpha coefficient for this scale was determined to be 0.606, a value that is within an acceptable range to conduct exploratory research (75).

3.2.2 Social use of WeChat

The measurement of the social use of WeChat was conducted using four questions that were adapted from the study conducted by Chang and Zhu (40). The participants were queried regarding the extent to which they agreed with statements pertaining to several aspects of WeChat usage, including "meeting new friends through WeChat," "maintaining communication with friends via WeChat," "keeping in touch with teachers and classmates through WeChat," and "accomplishing academic tasks through WeChat." Participants were requested to provide their feedback using a 5-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The cumulative values of four items were aggregated to assess the extent of social utilization of WeChat. The Cronbach's alpha coefficient for this scale was determined to be 0.710.

3.2.3 Entertainment use of WeChat

The researchers employed the revised three-item scale created by Guo et al. (34) to assess the extent of entertainment utilization of WeChat. The aforementioned projects encompass the examination of activities on the WeChat platform, the utilization of WeChat for entertainment purposes, and the engagement with WeChat as a means of passing time. The participants were also requested to provide their reaction using a 5-point Likert scale, ranging from 1, indicating "strongly disagree," to 5, indicating "strongly agree." The scale's Cronbach's alpha coefficient in this study was 0.819.

3.2.4 Bonding social capital

The researchers utilized the modified bonding social capital scale, established by Ellison et al. (76), to evaluate bonding social capital. The items include "I believe some friends can help me solve problems through WeChat" and "WeChat friends can help me solve the unfair things I have encountered." Participants expressed their agreement on the six questions, using a 5-point Likert scale (1 = "strongly disagree" to 5 = "strongly agree"). Higher scores indicate higher levels of bonding social capital. These scores were later summed to measure bonding social capital. Cronbach's alpha of the bonding social capital scale was 0.839.

3.2.5 Life satisfaction

The Satisfaction with Life Scale (SWLS), developed by Diener et al. (65), was utilized to assess individuals' levels of life satisfaction. The scale comprises five items, including statements such as "my life is roughly in line with my ideals" and "my life is very satisfactory." Participants were instructed to assess the degree to which they agreed with the statements using a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). The summation of scores for all items was conducted to assess the comprehensive measure of life satisfaction. The higher the score, the greater the level of life satisfaction. The present study yielded a Cronbach's alpha coefficient of 0.908 for this scale.

3.2.6 Loneliness

The measurement of loneliness was conducted using the social loneliness subscale of the Emotional vs. Social Loneliness Scale [ESLS; (77)]. The ESLS comprises two distinct subscales, namely

the social loneliness subscale and the emotional loneliness subscale. According to Russell et al. (78), social loneliness refers to the subjective experience of not having sufficient companionship, whereas emotional loneliness refers to the subjective experience of not having sufficient affectionate relationships. The social loneliness subscale is deemed more appropriate for the goal of conducting research. Participants were instructed to assess the caliber of the social encounter for a set of five items using a Likert scale ranging from 1 (indicating never) to 5 (indicating always). The questionnaire comprises three statements, namely, "it seems that everyone around me is a stranger," "I can be part of a circle of friends and become one of them," and "I cannot get much satisfaction from the group I participated in." The range of total scores spans from 5 to 25 points. The higher the score is, the stronger the loneliness. In this study, Cronbach's alpha of the questionnaire was 0.675.

3.2.7 Control variables

The demographic variables, including age, gender, and educational level, were controlled in accordance with prior studies (48, 79, 80).

3.3 Data analytical strategy

The analysis was performed sequentially, consisting of three distinct processes, utilizing the statistical software SPSS version 22. First, Microsoft Excel was employed to perform data cleansing and processing procedures on the raw data. Second, this study employed preliminary statistics and conducted an assessment for common method variance (CMV) utilizing SPSS 22.0. Furthermore, to evaluate the robustness of this measurement model, an analysis is conducted to test the reliability and validity of the constructs employed in the current study. Third, the presentation included descriptive statistics. This study employed correlation analysis to investigate the associations of WeChat use intensity, WeChat use motivations, bonding social capital, and mental health. To conduct a more comprehensive examination of the mediation impacts of WeChat use incentives, including social use and entertainment use, as well as bonding social capital, the bias-corrected bootstrap approach was employed. The methodology employed in this study utilizes an alternative sampling technique, whereby each individual instance has the potential to be selected numerous times to generate multiple samples (81). This strategy effectively mitigates the bias that may arise from a non-normal sampling distribution. The study employed Model 6 in the SPSS macro PROCESS v3.0 plugin to examine the sequential mediation effects. The present study employed a methodological approach to examine the mediating effect, utilizing the estimation of a bootstrap 95% confidence interval (CI) over 10,000 re-sampling iterations. According to Hayes (81), if the 95% CI does not include the value of 0, it indicates that the mediation effect is statistically significant.

4 Results

4.1 Common method bias tests

To mitigate the potential influence of common method bias, various procedural measures were employed. These efforts included the employment of anonymous personal information and the deliberate reversal of specific components of the projects throughout the data gathering phase. In addition, the utilization of Harman's single-factor test is employed to assess the existence of common method biases, as outlined by Podsakoff et al. (82). The results suggest that there exist eight common factors with feature roots above a value of one. The initial shared component, namely, accounts for 35.82% of the total variation, which is below the critical criterion of 40%. Therefore, it can be inferred that the presence of common technique bias is absent.

4.2 Bivariate correlations

Before examining the hypothesis, preliminary descriptive and correlational analyses are performed. The results of the descriptive statistics and correlation matrix are presented in Table 2. The findings presented in Table 2 demonstrate a significant positive association between the level of WeChat usage and its utilization for social purposes ($r = 0.307$, $p < 0.001$), entertainment use ($r = 0.223$, $p < 0.001$), and the development of bonding social capital ($r = 0.227$, $p < 0.001$). Additionally, a noteworthy negative correlation is observed between WeChat usage and feelings of loneliness ($r = -0.253$, $p < 0.001$). Moreover, a negative association has been observed between all four aforementioned qualities and the experience of loneliness. Furthermore, the study revealed that the utilization of social WeChat and entertainment WeChat had a notable positive impact on the cultivation of bonding social capital ($r = 0.409$, $p < 0.001$; $r = 0.384$, $p < 0.001$, respectively).

4.3 Serial-multiple mediation model outcomes

This study employed four serial-multiple mediation models to examine the relationships between WeChat use intensity, social use of WeChat, bonding social capital, life satisfaction, and loneliness. Specifically, the study investigated the mediation roles of the social use of WeChat and bonding social capital in the association between WeChat use intensity and life satisfaction, as well as the mediating roles of the social use of WeChat and bonding social capital in the effect of WeChat use intensity on loneliness. Additionally, the study explored the mediation roles of entertainment use of WeChat and bonding social capital in the effect of WeChat use intensity on life satisfaction, as well as the mediation roles of entertainment use of WeChat and bonding social capital in the effect of WeChat use intensity on loneliness. The present study utilized four serial-multiple mediation models to investigate the associations among the intensity of WeChat use,

TABLE 2 Means, SD, and zero-order correlations for all the key study variables ($N = 487$).

Variables	Mean	SD	1	2	3	4	5	6	7	8	9
Age	20.09	1.423	1								
Gender level	0.505	0.500	−0.018	1							
Education	2.33	1.136	−0.021	−0.136***	1						
WUI	59.343	20.534	−0.085*	0.061	0.061	1					
SUW	14.672	3.596	0.087*	−0.061	−0.071	0.307***	1				
EUW	10.062	3.334	−0.062	−0.043	−0.090**	0.223***	0.601***	1			
BSC	19.713	3.344	0.014	−0.023	−0.094**	0.227***	0.409***	0.384***	1		
LS	23.273	6.821	0.107**	−0.094**	−0.061	0.069	0.457***	0.496***	0.400***	1	
LL	12.546	3.188	0.076*	0.060	−0.079*	−0.253***	−0.268***	−0.219***	−0.451***	−0.311***	1

*p < 0.1, **p < 0.05, ***p < 0.01.

the social use of WeChat, bonding social capital, life satisfaction, and loneliness. The present study aimed to examine the mediating effects of the social use of WeChat and bonding social capital in the relationship between WeChat use intensity and life satisfaction. Additionally, this study sought to investigate the mediating effects of the social use of WeChat and bonding social capital in the impact of WeChat use intensity on feelings of loneliness. Furthermore, the research examined the mediating effects of WeChat's entertainment use and bonding social capital on the relationship between the intensity of WeChat use and life satisfaction. Additionally, it investigated the mediating effects of WeChat's entertainment use and bonding social capital on the relationship between the intensity of WeChat use and feelings of loneliness. Age, gender, and educational level were all controlled in the four models.

4.3.1 WeChat use intensity, social use of WeChat, bonding social capital, and mental health

The present study aimed to investigate the correlation between the intensity of WeChat usage and life satisfaction, while also exploring the potential mediating effects of the social use of WeChat and bonding social capital. The results shown in Figure 2 indicate that there was a significant relationship between the intensity of WeChat use and life satisfaction ($\beta = -0.032, p < 0.05$). Furthermore, the 95% confidence interval (CI) for the relationship between WeChat use intensity and life happiness, namely, through the social use of WeChat, did not include the value of 0 (CI = [−0.059; −0.005], as shown in Table 3). The intensity of WeChat usage has an impact on life satisfaction in three distinct manners, as outlined in Model 1. The impact of WeChat usage intensity on life happiness is mediated by the social use of WeChat. The findings of the study indicated a significant positive relationship between the intensity of WeChat usage and the social use of WeChat ($\beta = 0.058$, $p < 0.001$). The 95% confidence interval (CI) for the relationship between the intensity of WeChat use and life satisfaction, namely, through the social use of WeChat, did not include the value of 0 (CI = [0.026; 0.056], as shown in Table 3). Furthermore, the utilization of WeChat has been found to have an impact on individuals' life satisfaction by influencing the strength of their bonding social capital. The findings of the study indicate a significant positive correlation between the use of WeChat and the development of bonding social capital ($\beta = 0.695$, $p < 0.001$). Furthermore, the study reveals a positive association between bonding social capital and life satisfaction ($\beta = 0.548$, $p < 0.001$). In addition, the 95% confidence interval (CI) for the relationship between WeChat use intensity and life satisfaction through bonding social capital did not include the value of 0 (CI = [0.003; 0.020], as shown in Table 3). Third, the intensity of WeChat usage has an impact on individuals' life satisfaction, specifically through the social use of WeChat and the development of bonding social capital. The findings of the study indicate a significant positive association between the utilization of WeChat for social purposes and the development of bonding social capital ($\beta = 0.341$, $p < 0.001$). Furthermore, the 95% confidence interval (CI) for the relationship between WeChat usage intensity and life satisfaction, namely through the social use of WeChat and bonding social capital, did not include the value of zero (CI = [0.006; 0.016], as shown in Table 3). According to the research conducted by MacKinnon et al. (83) and Tzelgov and Henik (84), the appearance of a suppression effect can be observed within a mediation model when the direct and mediated effects of the independent variable on the dependent variable have opposing signs. The potential impact of utilizing WeChat lies in its ability to alleviate the negative effects connected with its usage on individuals' overall life satisfaction. This can be achieved through the promotion of social use motivation and the strengthening of bonding social capital. Hence, the utilization of WeChat for entertainment purposes exerts a suppressive effect on the association between the intensity of WeChat usage and life satisfaction.

Second, the present study examined the second mediation model, specifically focusing on the mediating role of the social use of WeChat and bonding social capital in the relationship between the intensity of WeChat use and feelings of loneliness. The results from Model 2, as depicted in Figure 2, indicate a strong negative association between the usage intensity of WeChat and feelings of loneliness ($\beta = -0.020$, $p < 0.01$). The initial findings indicate that there was no significant mediation impact of WeChat use intensity on loneliness through the social use of WeChat. The study found that there is no significant direct relationship between the intensity of social usage of WeChat and feelings of loneliness ($\beta = -0.068$, $p > 0.05$). The 95% confidence interval (CI) for the relationship between WeChat use intensity and loneliness, as

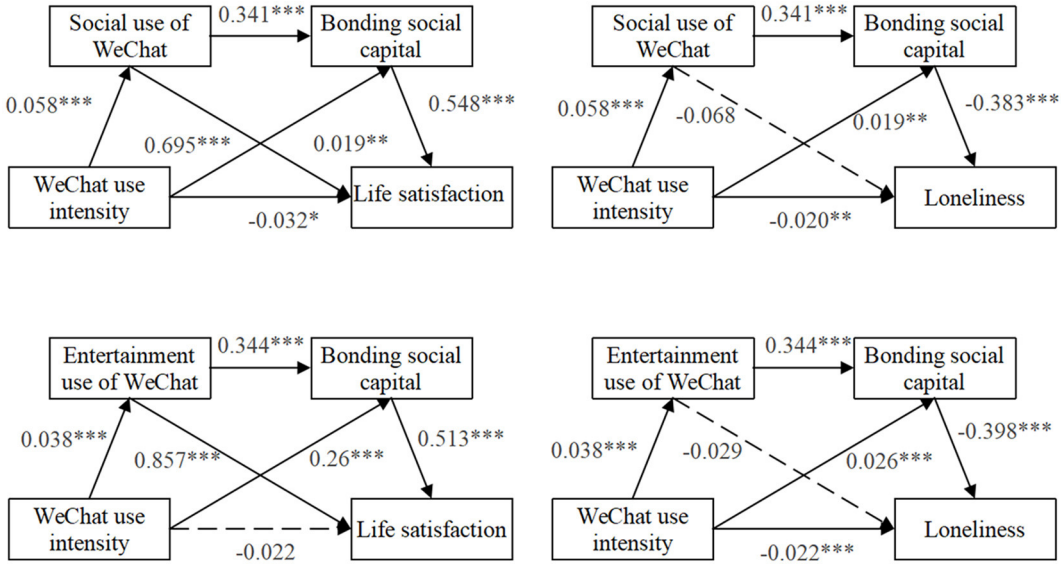

FIGURE 2
Serial mediation model shows effects of WeChat use intensity, WeChat use motivations and bonding social capital on mental health. Standardized regression coefficients were obtained after controlling for age, gender, and education level. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

measured by the social use of WeChat, ranged from −0.009 to 0.001 (CI = [−0.009; 0.001], see Table 3). Additionally, our study revealed a substantial mediation impact of bonding social capital in the relationship between the intensity of WeChat use and feelings of loneliness. The statistical analysis reveals a strong relationship between the intensity of WeChat use and the development of bonding social capital ($\beta = 0.019$, $p < 0.01$). The study found a statistically significant negative relationship between bonding social capital and loneliness ($\beta = -0.383$, $p < 0.001$). The results of the bootstrapping analysis revealed that bonding social capital had a significant indirect influence on the relationship between WeChat use intensity and loneliness. The coefficient for this indirect effect was −0.007, with a 95% confidence interval ranging from −0.014 to −0.002. These findings are presented in Table 3. Furthermore, it was shown that there was a significant direct effect of the intensity of WeChat use on the social use of WeChat ($\beta = 0.058$, $p < 0.001$). Furthermore, it is noteworthy that the impact of utilizing WeChat for social purposes on the development of bonding social capital was shown to be statistically significant ($\beta = 0.341$, $p < 0.001$). The relationship between the intensity of WeChat use and feelings of loneliness was found to be mediated by the serial pathway of WeChat use intensity leading to social use. The study found a significant negative relationship between the use of WeChat and feelings of loneliness, as shown by the confidence interval of −0.011 to −0.005 (95% CI), as shown in Table 3.

4.3.2 WeChat use intensity, entertainment use of WeChat, bonding social capital, and mental health

Third, this study examined the relationship between WeChat use intensity and life satisfaction with the mediation roles of entertainment use of WeChat and bonding social capital. As shown in Figure 2 Model 3, WeChat use intensity was not significantly associated with life satisfaction ($\beta = -0.022$, $p > 0.05$). The direct effect of WeChat use intensity on entertainment use of WeChat was significant ($\beta = 0.038$, $p < 0.001$). The direct effect of the entertainment use of WeChat on life satisfaction was significant ($\beta = 0.344$, $p < 0.001$). In addition, the 95%CI of WeChat use intensity to life satisfaction through entertainment use of WeChat does not contain 0 (IC = [0.002, 0.048, see Table 3]), indicating that the mediation effect of entertainment use on the relationship between WeChat use intensity and life satisfaction was significant. Furthermore, the direct effect of WeChat use intensity on bonding social capital was significant ($\beta = 0.26$, $p < 0.001$). The direct effect of bonding social capital on life satisfaction is significant ($\beta = 0.513$, $p < 0.001$). The 95% CI of WeChat use intensity to life satisfaction through bonding social capital did not contain 0 (IC = [0.006, 0.023, see Table 3]), indicating that the mediation effect of bonding social capital was significant. As shown in Model 3, the entertainment use of WeChat was significantly associated with bonding social capital ($\beta = 0.344$, $p < 0.001$). In addition, the 95% CI of WeChat use intensity to life satisfaction through both entertainment use of WeChat and bonding social capital did not contain 0 (IC = [0.003, 0.011, see Table 3]). Thus, in model 3, WeChat use intensity has effects on life satisfaction in three ways (WeChat use intensity→ entertainment use WeChat→ life satisfaction, WeChat use intensity→ bonding social capital→ life satisfaction, and WeChat use intensity→ entertainment use of WeChat→ bonding social capital→ life satisfaction; see Model 3).

Finally, this study tested the fourth mediation model: the mediation effects of entertainment use of WeChat and bonding social capital on the effect of WeChat use intensity and loneliness. As shown in Figure 2 Model 4, WeChat use intensity was significantly associated with loneliness ($\beta = 0.038$, $p < 0.01$).

TABLE 3 Summary of serial-multiple mediation results between WeChat use intensity and mental health ($N = 487$).

	Effect	BootSE	95% CI	
			BootLLCI	BootULCI
Direct effect of WUI on LS	−0.032	0.014	−0.059	−0.005
Indirect effect of WUI on LS				
WUI → SUW → LS	0.040	0.008	0.026	0.056
WUI → BSC → LS	0.011	0.004	0.003	0.020
WUI → SUW → BSC→ LS	0.011	0.002	0.006	0.016
Total effect of WUI on LS	0.061	0.009	0.044	0.080
Direct effect of WUI on LL	−0.020	0.007	−0.033	−0.007
Indirect effect of WUI on LL				
WUI → SUW → LL	−0.004	0.0023	−0.009	0.001
WUI → BSC → LL	−0.007	0.003	−0.014	−0.002
WUI → SUW → BSC→ LL	−0.008	0.002	−0.011	−0.005
Total effect of WUI on LL	−0.019	0.004	−0.027	−0.012
Direct effect of WUI on LS	−0.022	0.013	−0.048	0.003
Indirect effect of WUI on LS				
WUI → EUW → LS	0.032	0.008	0.002	0.048
WUI → BSC → LS	0.013	0.005	0.006	0.023
WUI → EUW → BSC→ LS	0.007	0.002	0.003	0.011
Total effect of WUI on LS	0.052	0.009	0.034	0.070
Direct effect of WUI on LL	−0.022	0.007	−0.035	−0.009
Indirect effect of WUI on LL				
WUI → EUW → LL	−0.001	0.002	−0.005	0.003
WUI → BSC → LL	−0.010	0.003	−0.017	−0.005
WUI → EUW → BSC→ LL	−0.005	0.002	−0.009	−0.002
Total effect of WUI on LL	−0.017	0.004	−0.024	−0.009

CI, Confidence interval; WUI, WeChat use intensity; LS, Life satisfaction; SUW, Social use of WeChat; EUW, Entertainment use of WeChat; BSC, Bonding social capital; LL, Loneliness.

First, we found that the mediation effect of WeChat use intensity on loneliness through entertainment use of WeChat was not significant. WeChat use intensity was positively associated with entertainment use of WeChat ($\beta = 0.038$, $p < 0.001$). However, the direct effect of bonding social capital on loneliness was not significant ($\beta = -0.029$, $p > 0.05$). The results of bootstrapping also revealed that the entertainment use of WeChat (coefficient = −0.001, 95% CI [−0.005, 0.003]) was not a significant mediator of the relationship between WeChat use intensity and loneliness (see Table 3). Second, the mediation effect of WeChat use intensity on loneliness through bonding social capital was significant. The direct effect of WeChat use intensity on bonding social capital was significant ($\beta = 0.026$, $p < 0.001$). Bonding social capital was reported to be significantly and negatively associated with loneliness ($\beta = -0.398$, $p < 0.001$). In addition, the indirect effect from bootstrapping also revealed that bonding social capital (coefficient = −0.010, 95% CI [−0.017, −0.005]) was a significant mediator of the relationship between WeChat use intensity and loneliness (see Table 3). Third, the direct effect of the entertainment use of WeChat on bonding social capital was significant ($\beta = 0.344$, $p < 0.001$). In addition, the 95%CI of WeChat use intensity to loneliness through the serial-multiple mediations of entertainment use of WeChat and bonding social capital did not contain 0 (IC = [−0.009; −0.002, see Table 3]). Therefore, the indirect impacts of WeChat use intensity on loneliness exist in two ways in model 4: WeChat use intensity→ bonding social capital→ loneliness and WeChat use intensity→ entertainment use WeChat→ bonding social capital→ loneliness.

5 Discussion

5.1 Summary of the key results

Based on the UGT theory and self-determination theory, this study attempted to systematically examine the underlying mechanism between WeChat use intensity and Chinese students' mental health, with a specific focus on WeChat use motivation (social use of WeChat and entertainment use of WeChat) and bonding social capital. The study revealed that the intensity of WeChat usage had significant effects on the degrees of life satisfaction and loneliness among college students in China, both directly and indirectly. Detailed findings are discussed below.

5.2 Mediation pathways from WeChat use intensity to mental health through social use of WeChat and bonding social capital

The present study investigated the mediating role of the social use of WeChat and bonding social capital in the relationship between WeChat use intensity and mental health, employing bootstrapping techniques for data analysis. The results indicated that the use of WeChat for social purposes played a mediating role in the relationship between the intensity of WeChat use and individuals' life satisfaction. This finding supports our hypothesis H1a. On the other hand, there was no observed correlation between the utilization of WeChat for social motivation

and feelings of loneliness. Thus, the H1b hypothesis was not substantiated. The results of the study indicate a favorable and significant correlation between the intensity of WeChat usage and its social use. The results suggest that a higher level of WeChat usage intensity may enhance individuals' motivation to engage in social interactions, aligning with prior studies that have found a positive association between WeChat usage intensity and social usage motivation (80). Furthermore, there was a favorable correlation between the utilization of WeChat for social purposes and individuals' life satisfaction. The results of the study also suggest that there is no significant relationship between the use of WeChat for social motivation and feelings of loneliness. This finding contradicts the earlier research conducted by Aydin et al. (85), which primarily focused on investigating the relationship between Facebook usage and loneliness. This may explain that the increased intensity of social media usage among college students may be associated with higher levels of social activity and cohesion within online networks, facilitating easier communication and interaction with friends, family, and relatives. Moreover, an increased number of connections can provide Chinese college students with greater options for self-expression and receiving recognition, thereby protecting against feelings of loneliness.

Second, this study indicated that students with high WeChat use intensity tend to experience a high level of bonding social capital, which in turn experienced better life satisfaction and lower loneliness. Therefore, H3a and H3b were supported. Previous research has also confirmed bonding social capital mediated the association between WeChat use intensity and mental health (18). Burke et al. (71) also demonstrated that low bonding social capital is significantly associated with higher loneliness. The finding may be explained by the psychological compensation theory (86). Online WeChat socialization can help people overcome the embarrassment and inconvenience of face-to-face communication, especially for introverted students. Additionally, in an era of fast-moving and modern society, with the acceleration of life pace, friends and family usually live in different places. WeChat, as an instant and real-time communication platform, can break through geographical restrictions, help keep in touch with social relationships, and seek psychological compensation (87), thereby reducing loneliness (18). However, the results of this study are inconsistent with the study by Hou et al. (88) that excessive use of WeChat had a negative impact on Chinese college students' loneliness. This is possibly because when college students mainly use WeChat at moderate intensity, which increases the opportunities for communication and self-presentation with others, it helps to obtain emotional support from family and friends (80). Furthermore, it is noteworthy to observe that there exist significant distinctions between the intensity of WeChat usage and the occurrence of excessive WeChat usage. The term "excessive use of WeChat" pertains to the psychological manifestation characterized by the intensity of psychological symptoms, including emotional fluctuations, anxiety, and interpersonal conflicts, resulting from the utilization of WeChat. Furthermore, Gao et al. (89) have established a correlation between the two variables, suggesting that the intensity of WeChat usage can serve as an indicator of excessive use of the platform.

Third, the findings of this study's serial mediation effects supported H4a and H4b, that is, students with high WeChat use intensity were sequentially linked with increased WeChat social use first and then improving their bonding social capital, which was, in turn, related to improvement in life satisfaction and decreased loneliness. The findings correspond with the studies that suggest SNS (especially WeChat) is becoming an indispensable part of personal daily life, which provides convenience for expanding the scope of contacts and facilitating social connections and social ties with other members (80, 90).

5.3 Mediation pathways from WeChat use intensity to mental health through entertainment use of WeChat and bonding social capital

This study conducted two serial mediation models to examine the mediators of entertainment use of WeChat and bonding social capital of the relationship between WeChat use intensity and life satisfaction and loneliness. First, the results of this study demonstrated that WeChat use intensity positively influenced students' entertainment usage motivation. This result is consistent with previous research results that social media contributes to relaxed use and time pass (91). Second, this study found that the more entertainment usage of WeChat, the better satisfaction with life. Therefore, this study proved H2a. The research indicated that the entertainment use of WeChat is not related to loneliness, which aligns with the findings of a longitudinal study conducted by Dienlin et al. (92). Hence, H2b is not verified. One possible explanation could be that the effects of media usage are contingent upon how individuals engage with it, rather than the specific type of media being consumed (21). This is because users can actively pursue and attain gratification in accordance with their personal objectives and motivations. In other words, various forms of media, such as WeChat, offer individuals a means to engage in fulfilling interpersonal interactions (93). WeChat has rich interactive functions such as chat, red envelope (hongbao), the circle of friends, "Like," and comments facilitating interpersonal communication (4, 94). It fully meets the communication needs of college students. Meanwhile, due to the traditional Chinese implicit culture, the use of social media can help students express their inner feelings that cannot be expressed face to face. Individuals frequently select captivating forms of entertainment, such as films, music, games, and the like, as a means to alleviate their perception of existential futility. Hence, the utilization of WeChat for recreational purposes does not exert any influence on the loneliness experienced by its users.

This study proved that the entertainment use of WeChat was positively associated with bonding social capital, which is inconsistent with a study by Guo et al. (34). Guo et al. (34) held that the entertaining use of social media might reduce the perception of social capital. The possible reason may be because Guo et al. (34) subjects are international students who are vulnerable to academic stress, acculturation stress, and mental diseases which are salient predictors of addictive smartphone behavior (95, 96). The

main reason may be explained that the utilization of WeChat for entertainment purposes does not inherently result in addiction and bad effects. In contrast, an increasing number of college students are utilizing applications such as WeChat games as a means to comprehend and reinforce preexisting social connections. Hence, the significance of the utilization motive may not be paramount; rather, its relevance lies in its alignment with internal requirements and its facilitation of the establishment of bonding social capital. Third, the findings of the serial mediation supported the hypothesis of H5a and H5b. Individuals who use WeChat for entertainment more frequently experience a higher level of bonding social capital, which in turn leads to greater life satisfaction and lower loneliness. Corresponding with the theoretical and empirical studies of social capital theory (50), SNS use for entertainment can help individuals make new channels to have leisure and recreational activities with friends (97), which can strengthen "strong tie" for users (98) and reduce their interpersonal distress (11).

In summary, social use of WeChat use motivation and entertainment use of WeChat use motivation both acted as a mediating effect on WeChat use intensity and mental health. It is imperative to not only ascertain the temporal aspects, frequency, and motivation of an individual's utilization of WeChat daily but also to comprehensively comprehend the nature of activities exhibited at the personal level, and to evaluate the potential influence on one's mental health.

5.4 Limitations and suggestions for future study

Various restrictions in the current research should be clearly addressed in future research. First and foremost, the interviewers were drawn from a single city, and the sample consisted primarily of young adults with an average age of 20.09 years. Furthermore, this research was constrained by money and time constraints, which, if expanded, would have considerably enlarged the sample size and thus improved the external validity of the research. Therefore, it is necessary to be cautious in extending the research results to other populations. Future research is recommended to further expand sample groups in different cultural-geographical circumstances and improve the test efficiency, making the findings more robust and persuasive. Second, due to the cross-sectional nature of the survey, the study did not establish a causal relationship among the main variables, including WeChat use intensity, WeChat use motivation, bonding social capital, and mental health. Longitudinal studies and experimental methods should be conducted further to investigate causal relationships among them in subsequent research. Third, it is worth considering the potential enrichment of the study model's dimensions. Future studies may benefit from incorporating individuality qualities, such as introversion or extroversion. Future studies might further investigate additional aspects of WeChat usage motives to examine their possible impact on mental wellbeing. Moreover, it is imperative to explore the psychological framework that is closely associated with Chinese culture to have a thorough understanding of the use of WeChat by individuals from China and other Asian nations. The concepts referred to include guānxì, which refers to interpersonal relationships, and mianzi, which pertains to face or social reputation. Furthermore, it is anticipated that the use of this methodology aimed at broadening the scope of research will yield more comprehensive and insightful findings. Ultimately, it is imperative to show prudence when extrapolating the conclusions of our investigation to diverse academic or social contexts, as well as to alternative social networking platforms.

6 Conclusion

The current study was the first to explore the relationship between WeChat use intensity and mental health among Chinese college students using the serial-multiple mediation model. This article finds that WeChat use intensity had both direct and indirect impacts on the levels of life satisfaction and loneliness experienced by college students in China. Specifically, the utilization of WeChat for social motivation and entertainment motivation was found to have a suppressive effect on the relationship between the intensity of WeChat usage and individuals' life satisfaction. The association between the intensity of WeChat usage and mental health outcomes (life satisfaction and loneliness) was found to be mediated by bonding social capital. Furthermore, the association between the intensity of WeChat usage and mental health was found to be mediated by the sequential mediation effects of using WeChat for social motivation and bonding social capital, as well as the sequential mediation effects of using WeChat for entertainment motivation and bonding social capital. The present study not only confirmed the suitability of the self-determination theory and the UGT theory for the usage of SNS but also provided insights into potential intervention strategies for Chinese adolescents.

From a theoretical viewpoint, this research has made several significant contributions to the studies of WeChat use and mental health. First, a large body of theoretical and empirical studies has examined the relationship among SNS utilization, SNS use motivations, social capital, and mental health (19, 27, 34, 41). However, no studies have examined the serial mediation effects of motivations and bonding social capitals on the relationship between WeChat use intensities and mental health. The current study contributed to clarifying the indirect mechanisms of how time spent on WeChat leads to better mental health. The obtained results of this research firstly discovered the support of the chained mediation role of two types of WeChat use motivations and bonding social capital on the relationship between WeChat use intensity and mental wellbeing, which shed light on the research of WeChat's impacts on subjective wellbeing.

Second, the current research also highlighted some practical implications. The results show that the time spent on WeChat can improve the mental health of college students. This may be because the use of WeChat provides convenience for college students' social interaction, meets their social and entertainment needs, and strengthens the social capital of college students. Based on the findings, it is suggested that proper and scientific use of new media will exert positive effects on college students' psychological wellbeing. Therefore, policymakers and practitioners are recommended to develop new perspectives on how WeChat use intensity affects mental health. Finally, specific online activities that not only meet social and recreational gratifications but can

promote students' social capital are highly recommended for college students.

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 was not required for the study of human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

MX and JL drafted and conducted the manuscript. MX contributed to the processes of modeling, data analysis, original writing, revision, proofreading, and finalizing of the manuscript. JL contributed to the revision, proofreading, and finalizing of the manuscript. All authors contributed to the article and approved the submitted version.

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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

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Mixed Reality for a collective and adaptive mental health metaverse

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This research paper explores the significant transformative potential of Mixed Reality (MR) technology as enabler of the metaverse, specifically aimed at enhancing mental health therapies. The emerging world of the metaverse, a multiuser, adaptive, three-dimensional digital space, paired with the interactive and immersive benefits of MR technology, promises a paradigm shift in how mental health support is delivered. Unlike traditional platforms, MR allows for therapy within the comfort of the user's familiar surroundings, while incorporating the benefits of social collaboration and interactions. The metaverse environment fosters heightened personalization and deeper user engagement, thereby offering a more tailored approach to computerized therapy. Beyond its immersive capabilities, MR offers potential for real-time, smart adaptations to the users' psycho-physiological state, targeting unique patients' needs on a diverse spectrum of therapeutic techniques, thus broadening the scope of mental health support. Furthermore, it opens avenues for continuous emotional support in everyday life situations. This research discusses the benefits and potentials of integrating MR within a mental health metaverse, highlighting how this innovative approach could significantly complement traditional therapeutic methods, fostering improved treatment efficacy, focusing on social and collective experiences, and increasing patient engagement.

KEYWORDS

metaverse, extended reality, mental health, Mixed Reality, adaptive interactions, collaborative experience

1 Introduction

In recent decades, mental health concerns have garnered significant attention as they emerge as one of the most pressing global public health issues. The prevalence of mental health disorders has been on a steady rise, impacting individuals from all walks of life and transcending geographical boundaries (1). Historically, mental health treatment predominantly focused on individual therapy, which currently accounts for 95% of private practitioners' sessions (2). However, in the wake of increased recognition of the social dimensions of mental health and the powerful impact of community support, the paradigm of mental health treatment has evolved over time. Group therapy and support groups have established as complementary interventions to individual therapy, offering distinct benefits. For example, fostering a sense of belonging and connection (3). In addition, support groups help reduce feelings of isolation and stigmatization, offering participants an environment where they can be understood and validated by their peers navigating similar struggles (4). These groups also offer a unique platform for participants to witness the growth and progress of others, providing a sense of hope and inspiration (5).

The adoption of group therapy for addressing mental health challenges is not without barriers (6–8). Geographical limitations, such as inaccessibility to mental health resources in

rural areas, hinder participation. Stigma surrounding mental health may deter individuals from joining group sessions (9). Pandemics and crisis situations pose unique obstacles, necessitating virtual platforms that may be inaccessible to some due to technological limitations. Interpersonal challenges within groups can affect therapeutic efficacy. In certain situations, such as severe mental health conditions, cognitive impairments, or with individuals exhibiting potentially harmful behavior, group therapies may not be immediately feasible or suitable. Cultural and language barriers can also impact communication and trust (10). Addressing these challenges is essential to create inclusive and effective therapeutic environments, fostering collective healing and resilience in the face of mental health struggles.

Emerging technologies, such as Extended Reality (XR), offer promising alternatives to overcome such barriers. XR refers to a spectrum of technologies that blend the physical and digital realms (11) (see Figure 1). At one end of this spectrum, Virtual Reality (VR) provides users with complete immersion into computer-generated environments, typically achieved through head-mounted displays (HMDs) that block out the physical world. At the opposite end, Augmented Reality (AR), overlays digital elements onto the user's physical environment, but with limited interactive capabilities. Mixed Reality (MR) bridges the gap between VR and AR, allowing users to interact with both virtual and physical elements in real-time and within the same spatial context.

In this regard, immersive environments are capable of eliciting emotional responses in the person using them (13), making XR-based interventions very useful tools to address different aspects of mental health. Transversal to mental health, emotional regulation (ER) studies how individuals influence which emotions they have, when they have them, and how they experience and express them (14). There is consistent evidence showing the presence of ER difficulties in a wide range of mental disorders, suggesting that emotion dysregulation is an important factor to target in clinical interventions (15). In addition, the social dimension is also very relevant for ER: social interactions and interpersonal relations might elicit different emotional responses or even be used after emotional experiences to help individual's regulation (16). Hence, XR arises as a powerful means to practice emotional regulation strategies in a social and multicultural environment, opening a wide range of possibilities to create immersive and collective therapeutic activities. This manuscript will review how XR technologies can help support emotional regulation practices (Section 2), discuss how MR could provide the basis for a mental health metaverse that addresses ER strategies, its the benefits and potentials (Section 3), and concludes by highlighting how current and future research could help build such an accessible and inclusive mental health metaverse.

2 Literature review

2.1 Supporting mental health in XR through emotional regulation strategies

XR technologies have been widely used in mental health for the past two decades, showing promising potential in helping individuals learn and practice emotional regulation skills. VR and AR are especially interesting as a means to conduct Exposure Therapy (ET). They allow replicating scenarios in a simulated and controlled manner for progressive exposure, making it ideal for exposing patients to a scenario that elicits a specific emotion in them. VR also helps patients who might experience difficulties engaging in visualization-based practices often required when using ET techniques. Related work has explored the use of VR for ET in the treatment of various phobias (17–20), post-traumatic stress disorder (21), or to overcome social phobia (22). VR is also a helpful resource for treating eating disorders, reducing food-related craving and anxiety by gradual exposure to virtual representations of food (23), or using digital avatars to diminish negative body-related emotions in Mirror exposure therapy (MET) (24).

Attentional strategies such as mindfulness, breathing exercises or relaxation techniques, can also be supported by XR experiences. ZenG (25) proposes a MR application for kinesthetic meditation, i.e., centered on activities such as walking, gardening, etc. Based on the cognitive state captured by an EEG device, the color of the environment will change to show how the user is performing. Instead, Amores et al. (26) focused on internal reflection, developing a VR environment that procedurally generates 3D creatures, and changes the lighting of the environment to reflect users' internal state based on EEG, EDA and HR.

Breathing exercises have shown to decrease stress and improve feelings of relaxation, and their practice can be supported by digital games aimed at improving users' wellbeing. For example, Life Tree (27) is a VR experience that proposes three different scenarios to practice breathing exercises by using breathing biofeedback. Another VR game is DEEP (28), designed for children with anxiety, who are encouraged to explore an underwater fantasy world to practice diaphragmatic breathing.

Several works have focused on serious games and game mechanics to offer alternative ways of approaching adolescents mental health. For example, InMind is a VR game explicitly designed to intervene in people's beliefs about the malleability of emotions (29). Thanks to game-based mechanics, VR therapeutic experiences can increase adolescents engagement, attendance and adherence to treatment in comparison with traditional interventions like role-plays (30).

Various XR therapeutic interventions aimed for individuals reported that participants around the patient using the device also intervened in the therapeutic activity (31, 32), either providing advice or asking questions to the current participant. Sharing the same physical space in XR interventions can increase socialization and interactions between patients and therapists. However, remote therapeutic interventions could also benefit from group sessions: Dilgul et al. (33) evaluated a VR social experience to deliver cognitive behavioral group therapy (CBGT) for patients with depression. The VR scenario allowed patients to interact with each others remotely via avatars, and this anonymity increased participation and patients' willingness to talk more honestly.

There is a growing interest in recent years in applying XR technologies for ER settings (34). However, the majority of related works are based on immersive ET, focusing on reproducing real world settings within controllable and customizable virtual scenarios. This leaves unexplored plenty of other potential therapeutic approaches that are based on more creative contexts,

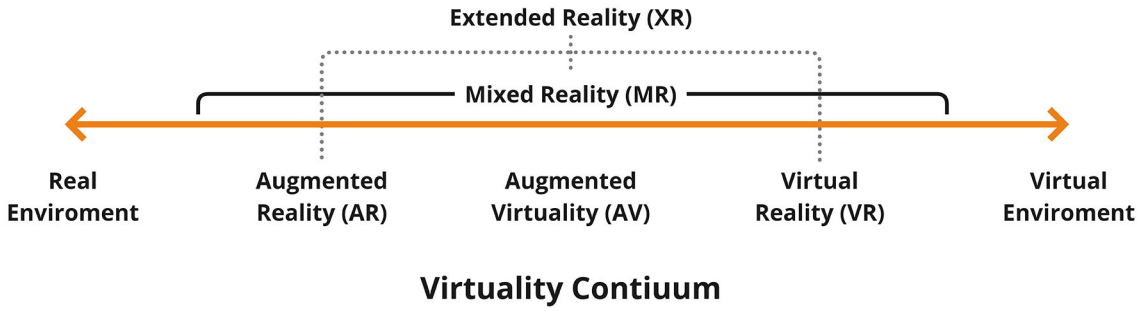

FIGURE 1
Extended reality continuum [adapted by (12) from (11)].

showing that the whole potential of XR technologies is far from being fully achieved. Especially, there is a lack of shared, social experiences and group activities, and the use of game mechanics as a way to motivate participants and encourage adherence to the therapy should be further explored. In addition, each XR scenario is usually designed and implemented to treat specific and precise mental health issues, and might not be applicable to other diagnoses or patients. Different technological solutions might present different architectures and even the supported devices which might not be compatible. This is an inefficient process for therapists and professionals, who do not have time to incorporate several XR solutions to their practice. Therefore, there is need for a cohesive and integrative platform that supports a variety of devices, therapeutic activities and customization options: the mental health metaverse.

2.2 A brief introduction to the Metaverse

The term "Metaverse" has become a focal point of curiosity, expectations, fears, and uncertainties in the modern era. As part of the postmodern quest to coin new terms that mark uncharted territories, the concept of the Metaverse represents a new dimension of the internet, promising to revolutionize our lives permanently. Metaverse encompasses a broader concept that includes virtual worlds, extended reality (XR) experiences, and other digital spaces where users can interact with each other and digital content in real-time. It refers to a shared, interconnected, and persistent virtual space that goes beyond individual applications or games. Users can create avatars, socialize, trade, conduct business, and engage in various activities within these virtual environments.

The Metaverse concept can be materialized accross different technologies, being those under the XR umbrella the most appropriate, mostly by their immersive capabilities. Immersion (35), represents the capacity of a technology to deliver highly engaging and interactive experiences, fully transporting users into virtual, augmented, or mixed environments. XR technologies strive to blur the boundaries between the physical and digital worlds, creating a strong sense of presence and involvement within the digital environment. From immersion, it could be inferred the feeling of presence. The sense of presence (36), traditionally associated to the feeling of "being there (in the digital world)" is strongly related to non-mediated technology-based experiences and suspension of disbelief. The concept of presence is multidimensional, attending to the wide XR spectrum consists of three major dimensions. The first one is telepresence, which is characterized by the extent to which a user experiences a sense of "reality" within the virtual environment as opposed to the physical one (37). This dimension of presence is associated to Virtual Reality. The second dimension refers to local presence, indicating the extent to which a user perceives augmented reality (AR) objects as truly existing in their immediate physical surroundings (38). This dimension is closely linked to Augmented Reality and Mixed Reality. The third dimension, co-presence, is limited to multi-user immersive experiences and refers to the psychological connection between participants and how real those social interactions are perceived to be (39).

The Metaverse builds upon the capabilities of these XR technologies, weaving them together to form a collective virtual universe that enables social interactions, commerce, entertainment, and educational experiences, fostering the three dimensions of presence previously defined. While VR focuses on transporting users to entirely digital environments (telepresence), AR (local presence) enhances the real world with digital overlays. MR (local presence) augments the feeling of presence since holograms are able to interact with the real world. All three approaches are able to implement co-presence scenarios, with higher or lower level of presence, since they all can be set up as multi-user environments.

3 The mental health metaverse

3.1 The role of Mixed Reality in a social metaverse

As can be observed in the literature of XR for mental health, VR and AR are the most common technologies being used. However, the devices used for the deployment of this type of applications are often not very accessible and inclusive. For example, VR implies that the person must wear glasses that visually isolate them from the real location where they are, so that the relationship between what the eyes perceive in the virtual world and the physical movements perceived through the vestibular system of the ear (responsible for spatial orientation and balance) is lost. Hence, VR sometimes leads

to severe Visual Induced Motion Sickness (VIMS) and accessibility problems (40), especially in people with high levels of stress (41). In the case of AR, its consumption is often linked to devices such as mobiles or tablets, thus sacrificing almost all of the immersion, but, as a trade-off, they have almost no VIMS problems (42, 43).

In contrast, in the field of mental health, there are hardly any interventions that make use of MR. However, MR constitutes a very interesting intermediate point between VR and AR: it allows a relevant degree of immersion, fostering local and co-presence, while avoiding VIMS problems, and in turn offers a wide variety of possibilities for natural interaction and the combination of the physical and digital worlds (44). This combination of both worlds allows to create rich scenarios, and paves the way toward more social and co-located experiences, which could be applied both in remote or in-person group therapies. Remote collaborative activities could be mediated by the use of avatars, that will be displayed by the HMD in the real environment of each participant. In-person group therapies will involve participants in the same physical spaces, some or all of them wearing MR headsets in which the same digital scenario is shared. In addition, MR facilitates that users perform their therapeutic activities in any space: MR applications can be designed to recognize surfaces and obstacles thanks to the depth cameras of MR devices, hence the digital content can adequate itself to the identified location and elements. It also allows therapists to have an intermediate step between practicing therapeutic activities in the clinic, and performing them in daily life, by first practicing using MR support in one's own real environment.

3.2 Adaptive and customizable experiences

Given the great variability of possible situations, the personal evolution and progression of each person, as well as individual preferences and responses, it is complex to configure this type of environments manually. Some works propose variants of each exercise with different difficulties (32). Other works offer tools to support the therapist's decision. For example, Heyse et al. (45) have developed a prototype adaptive algorithm for VR exposure therapy that automatically offers the therapist four different configurations to choose from, based on the patient's data, as well as allowing the modification of certain parameters such as blurring or flickering lights. This makes it easy to configure and customize the scenario without the need for technical expertise. However, these approaches are costly because they involve different developments and are not suitable for all needs.

Therefore, an essential aspect in this type of environments is that the XR experience intelligently adapts its content and goals to the user's need, instead of requiring therapists to manually set up each possible configuration. In this way, instead of preparing multiple options and outcomes for the same scenario, designers and developers could focus their efforts in the implementation of brand new therapeutic activities, that will adapt autonomously based on the necessary parameters defined by the professionals. In this regard, adaptive XR scenarios can leverage the potential of users' biofeedback to improve their response to stimuli and to adapt the environment to the defined parameters in an intelligent and automatic way. This biofeedback has to be presented in a way that does not evoke categorizations of behavior as right or wrong, i.e., the user does not feel evaluated or judged (46). In addition, feedback based on bodily sensations and represented in the experience in a subtle way is recommended (47), contextualized with the experience and in a non-distracting way (46). This could allow to adapt the therapeutic activity to the patients' current mood and emotions, in a similar way as therapists would adapt traditional interventions to the group's needs. Moreover, this intelligent adaptation would facilitate the definition of the technological intervention of a specific patient: the system could provide different therapeutic activities from which the therapist could choose the most appropriate ones, and the system will be responsible for adapting its content to the specific requirements of that user.

3.3 Shaping a modular and collaborative metaverse

In the emerging mental health metaverse, conventional group therapies can be re-imagined and conducted in dynamic and innovative ways (see Figure 2). Within this interconnected digital realm, participants can come together in their own digitally augmented safe physical space. Users could be offered the opportunity to explore different virtual worlds, each of them with its own particular aesthetic and narrative traits. These worlds would be populated with interactive activities, thoughtfully co-designed by therapists and XR professionals to address specific mental health skills that transcend various pathologies and disorders. For example, one such world could focus on ludic therapeutic activities to avoid rumination and intrusive thoughts, while another world could be aimed to practice self-compassion, providing diverse therapeutic activities where users learn how to deliver kindness toward themselves.

Therapists and mental health professionals would play a vital role in creating, curating and updating these therapeutic activities, incorporating evidence-based approaches and different therapeutic modalities. Working together with XR designers and developers they would shape this collective and adaptive space. The mental health metaverse would act as a complementary and accessible extension, in time and space, of traditional therapy, enabling individuals to reinforce their learning and coping skills beyond scheduled sessions.

The therapeutic activities could be reused in different worlds within the metaverse, to be used by both their patients as well as to people who might be in need, hence reaching other communities and diverse populations. Users have the freedom to access these tailored experiences at their convenience, fostering a self-directed and flexible approach to mental health care. In this way, users would be able to explore different emotional regulation strategies that resonate with them, either accompanied by their therapists or in a self-guided journey, but always in a controlled and supportive social environment.

In these collaborative metaverse, the concept of co-presence plays a pivotal role in shaping the perception of social interactions with other participants. Through the seamless blending of digital

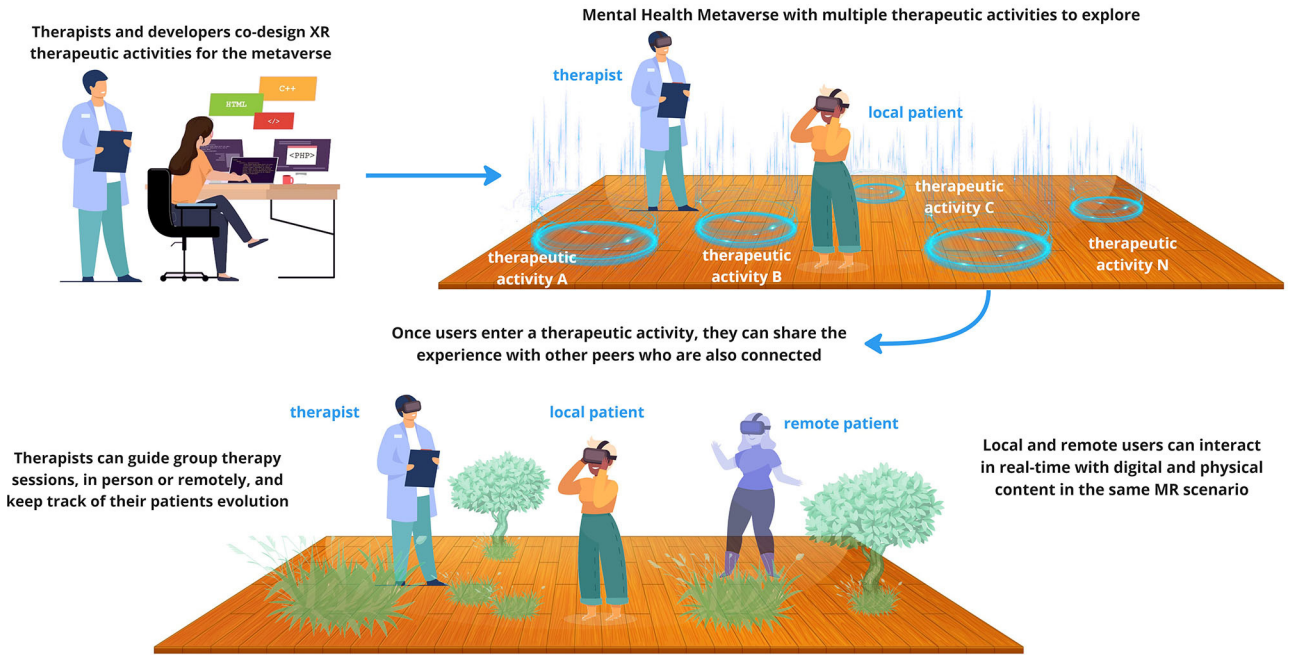

FIGURE 2
Depiction of the mental health metaverse, showing co-located in-person and remote interactions in Mixed Reality (imaged created with designs from Vecteezy.com, FreePik, and pch.vector from https://www.freepik.com/).

and physical-world elements, users can experience a heightened sense of being physically present with others, despite the physical separation. This sense of co-presence can lead individuals to believe that the other participants within the metaverse are real, due to the compelling and realistic nature of the shared virtual environment (48). The psychological connection fostered by this perceived presence of others contributes to a more authentic and emotionally engaging social experience within the metaverse, further enhancing the sense of social realism and immersion in these interactive XR environments.

Additionally, the multi-user nature of metaverse design encourages spontaneous collaboration among users, fostering a supportive and interconnected community of individuals striving for mental wellbeing. On one hand, users would be able to meet other peers in the specific therapeutic activities they are navigating, by collaborating with them within the activities toward a common goal, in a virtual group therapy session, etc. On the other hand, the metaverse offers ways to explore, navigate and discover the different therapeutic activities that are available. In this journey, users can see the avatars of other peers also exploring the area, where spontaneous interactions and conversations might happen. In these way, users can share experiences, provide mutual encouragement, and gain insights from each other's journeys, creating a powerful network of collective healing. Besides the therapeutic activities, therapists could also facilitate group sessions, providing real-time guidance and interventions, while participants can engage in open discussions, emotional expression, and active support for one another.

Through the use of avatars, individuals will be able to represent themselves, interact with their therapist and with other users, navigate and engage with therapeutic content and exercises. The use of avatars is intended to promoting anonymity, reducing the stigma often associated with traditional face-to-face group therapy, and increasing comfort and willingness to engage (33), without diminishing the feeling of co-presence.

In the mental health metaverse, participants can seamlessly join group sessions either remotely or in person, thanks to the versatility of MR technology. This integration enhances accessibility and fosters a diverse and inclusive therapeutic environment. Those who are physically present in the same location can engage with augmented digital elements together, promoting real-time interpersonal interactions and mutual support. Simultaneously, individuals from remote locations can connect to the same virtual space, ensuring they can actively participate and collaborate in the group sessions from the comfort of their own surroundings. This blended approach holds the potential to enhance the sense of connectedness, support, and interpersonal interaction, making therapy sessions more immersive and impactful, enabling collective healing and growth transcending geographical boundaries.

4 Conclusion

The metaverse harbors the potential to revolutionize mental health care, breaking down geographical barriers, reducing stigma, and providing accessible and engaging interventions. With its user-driven nature and collaborative environment, the metaverse offers a transformative landscape where collective healing and growth can flourish, empowering individuals on their journey to better mental wellbeing. For mental

health practitioners, the metaverse is poised to emerge as an invaluable instrument, as it will enable them to elevate their therapeutic sessions to a higher level, expanding their scope of practice (geographically and socially) and creating ludic environments that enhance accessibility and adherence of treatments.

Anticipating the future, these XR experiences may incorporate haptics, smell, and seamless biofeedback, thereby increasing presence, which could improve the effects of the treatments for the users (49). The rise of generative AI has the potential to significantly enhance the metaverse by improving its intelligent capabilities, facilitating adaptation and personalization. The user experience of MR technologies is expected to greatly improve in the upcoming years, thanks to the advances in hardware devices capabilities and their seamless integration into everyday activities. Efforts to improve accessibility in MR will lead to interfaces designed to accommodate a diverse range of users, including those with physical and cognitive disabilities. This focus on accessibility will make MR experiences more inclusive and usable for a broader audience. While challenges and ethical considerations remain, the mental health metaverse could provided a motivating, social and specialized platform that helps fight the stigma and eases the way to people who currently struggle to find and adhere to their therapeutic process.

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.

Author contributions

SN-M: Writing—original draft, Writing—review & editing. JS-D: Writing—original draft, Writing—review & editing. PP: Writing—original draft, Writing—review & editing.

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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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Using structural equation modeling to explore the influences of physical activity, mental health, well-being, and loneliness on Douyin usage at bedtime

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Douyin is the Chinese version of TikTok. Using Douyin at bedtime is a very common behavior among Douyin users. However, the reasons why users like using Douyin before sleep are yet unclear. We conducted a cross-section survey from January 1st to January 16th, 2023 to capture data to examine the associations of depression, anxiety, life satisfaction, well-being, loneliness, and physical activity with Douyin usage at bedtime. The mediation role of insomnia in these associations was examined. A total of 3,392 participants who met the inclusion criteria were included for analysis. Our structural equation modeling analysis showed that depression on ($\beta = 0.08$; $p < 0.05$), anxiety ($\beta = 0.06$; $p < 0.05$), and loneliness ($\beta = 0.14$; $p < 0.05$) were directly associated with increased Douyin usage at bedtime, and were also indirectly associated with Douyin usage through insomnia (depression: $\beta = 0.18$; $p < 0.05$, anxiety: $\beta = 0.16$; $p < 0.05$, and loneliness: $\beta = 0.12$; $p < 0.05$). Life satisfaction ($\beta = -0.05$; $p < 0.05$) and well-being ($\beta = -0.20$; $p < 0.05$) were directly associated with decreased Douyin usage at bedtime, and were also indirectly associated with Douyin usage through insomnia (life satisfaction: $\beta = -0.09$; $p < 0.05$, and well-being: $\beta = -0.11$; $p < 0.05$). However, physical activity was unexpectedly associated with increased Douyin usage at bedtime ($\beta = 0.20$; $p < 0.05$). In conclusion, our findings shed new light on the specific reasons why Douyin users like using Douyin at bedtime.

KEYWORDS

physical activity, public health, mental health, social media, domain-specific behaviors

1 Introduction

Douyin, the Chinese version of TikTok, is an emerging short-video sharing platform. Currently, this type of short-video sharing platform has gained worldwide popularity. According to data from the China mobile internet big data company, as of May 2023, Douyin boasts over 700 million active users in China, dedicating an average of 36.6 h per month to the platform (1). It has already become the most widely used social media app in China (1). Worldwide, the international version of Douyin (TikTok) is available in over 160 countries, with a user base of 1.677 billion as of 2023 (2). Given such influence, some governments even use it as a platform for policy announcements (3), making it an integral part of daily life. Furthermore, based on our topic search in the Web of Science database, there has been a significant rise in publications related to Douyin/TikTok (4). In 2020, 58 studies were published; this number surged to 230 studies in 2021 and further increased to 459 studies in 2022 (4). Therefore, there is an increasing research interest in Douyin.

In the past few years, numerous studies have been conducted to investigate the impact of Douyin on public health. For instance, Sha and Dong (5) investigated Douyin's effects on adolescents, revealing that excessive Douyin usage may lead to mental health problems and memory loss. Zhang et al. (6) uncovered that nighttime Douyin use was positively associated with delayed sleep and poor sleep quality. Additionally, other negative consequences arising from Douyin use have come into focus, including anorexia (7), cyberbullying (8), and negative mood (9). These findings consistently highlight the adverse effects of Douyin usage. However, there is less knowledge about the factors driving Douyin usage, particularly domain-specific usage behaviors.

Using Douyin at bedtime is a domain-specific use behavior that is prevalent among Douyin users. A cross-sectional study conducted by Zhang et al. (6) revealed that more than 85% of Douyin users engage in this use behavior. According to previous studies, mental health problems, such as depression and anxiety, are common factors linked to excessive social media use behavior. Regarding Douyin, Zhang et al. (6) also suggested a potential association between mental health and nighttime Douyin usage behavior. Thus, we formulated the hypothesis (H1) that depression and anxiety are associated with increased Douyin usage at bedtime. Well-being and life satisfaction have also been associated with excessive social media use (10). Previous studies have demonstrated that well-being and life satisfaction can be used to predict social media addiction (11, 12). Considering that Douyin dependence at night might be one manifestation of social media addiction, we formulated the hypothesis (H2) that well-being and life satisfaction are negatively linked to Douyin usage at bedtime. Loneliness is another risk factor for excessive social media use, as individuals experiencing loneliness tend to use social media more frequently than their counterparts (13). Currently, there is limited research on the relationship between Douyin usage at bedtime and loneliness. However, some studies suggest that people may use social media at night due to feelings of loneliness resulting from missing out on messages (14, 15). Therefore, we formulated the hypothesis (H3) that there is an association between loneliness and increased Douyin usage at bedtime.

Physical activity is typically considered a potential protective factor against excessive social media use (16, 17). However, there are currently fewer researchers focusing on the relationship between physical activity and nighttime Douyin usage. In this aspect, only some researchers suggest that the stress-reducing benefits of physical activity might have a positive impact on alleviating nighttime Douyin usage (6). Therefore, we formulated the hypothesis (H4) that there is a negative association between physical activity and Douyin usage at bedtime. Finally, insomnia may play a crucial mediating role between the aforementioned factors and Douyin usage. This is because insomnia is not only predicted by depression (18, 19), anxiety (18, 19), well-being (20), life satisfaction (21), loneliness (22), and physical activity (23), but is also associated with excessive social media use (24), especially during bedtime (25). Thus, we formulated the hypothesis (H5) that insomnia acts as a mediator between the variables of interest and Douyin usage at bedtime. Given the possibility of confounding in these relationships (26, 27), we included age and gender as covariates. According to our hypotheses, we developed conceptual models as follows (Figure 1).

2 Materials and methods

2.1 Study design and participants

We conducted a cross-section survey from January 1st to January 16th, 2023. Initially, a preliminary questionnaire was developed by the author(s) following a literature review. Subsequently, this questionnaire was refined based on the feedback received from a pilot study involving 17 participants. The final formal questionnaire was uploaded to the "Sojump" (www.sojump.com). The Sojump is one of the biggest professional online platforms for questionnaire design, questionnaire distribution, data collection, and data analysis in China (28). To distribute the questionnaire, we enlisted the help of 45 college students, who shared a quick response (QR) code linked to our survey through various online chat groups, including WeChat, Tencent QQ, and other social media platforms. We described the study's topic as investigating reasons why people like using Douyin. Details of the research questions were not disclosed during participant recruitment. We offered compensation of 5 CNY (approximately 0.8 USD) for completing the survey. Participants were required to use WeChat accounts that liked their personal IDs to fill out the questionnaires. Their device, WeChat ID, and IP address were restricted to avoid repeated participation. This study was approved and supervised by the Ethics Review Board of Southwest University.

Inclusion criteria: (i) Age $\geq$ 18 years; (ii) Douyin usage of at least 1 h per day in the past month. Exclusion criteria: (i) Absence of informed consent; (ii) Unfinished questionnaires; (iii) Individuals who failed verification tests (to confirm that the questionnaire was carefully completed by people instead of a machine or program or random filling).

2.2 Instruments and measurements

2.2.1 Depression

In this study, we assessed depression using the Patient Health Questionnaire (PHQ-9) (29). The PHQ-9 comprises nine questions based on the nine criteria for a major depressive episode outlined in the DSM-IV. Each question prompts respondents to indicate the frequency of depressive symptoms they experienced in the 2 weeks

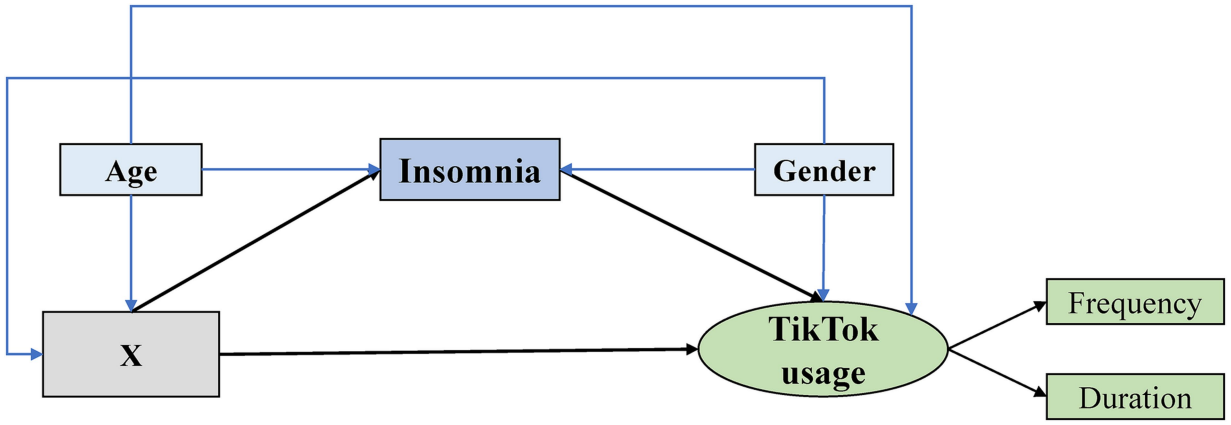

FIGURE 1
Conceptual framework (Black lines indicate pathways between core variables, and blue lines indicate confounding pathways between core and control variables. X, independent variables such as depression, anxiety, and loneliness.).

preceding the survey, with scores ranging from 0 (not at all) to 3 (nearly every day). We utilized a Chinese version of the PHQ-9, which demonstrated strong internal consistency in the current study (Cronbach's $\alpha > 0.9$).

2.2.2 Anxiety

In this study, we assessed anxiety using the Generalized Anxiety Disorder (GAD-7) (30). The GAD-7 is a self-report instrument consisting of seven items. Each item corresponds to one of the hallmark symptoms of generalized anxiety disorder (GAD) and is rated based on the frequency of experiencing that symptom over the preceding 2 weeks (Not at all, 1 = Several days, 2 = More than half the days, and 3 = Nearly every day). We utilized a Chinese version of the GAD-7, which demonstrated strong internal consistency in the current study (Cronbach's $\alpha > 0.9$).

2.2.3 Life satisfaction

In this study, we assessed life satisfaction using the Satisfaction with Life Scale-5 (SWLS-5). This scale comprises five self-report items designed to evaluate an individual's overall satisfaction with their life. Participants were instructed to rate their agreement with each statement on a 7-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Slightly Disagree, 4 = Neither Agree nor Disagree, 5 = Slightly Agree, 6 = Agree, 7 = Strongly Agree). We utilized a Chinese version of the SWLS-5 which demonstrated strong internal consistency in the current study (Cronbach's $\alpha > 0.9$).

2.2.4 Well-being

In this study, we assessed well-being using the World Health Organization-Five Well-Being Index (WHO-5). This index consists of five self-report items designed to measure an individual's overall sense of well-being and positive mental health. Participants were asked to rate their feelings and experiences over the past 2 weeks, using a 6-point Likert scale (0 = At no time, 1 = Some of the time, 2 = Less than half of the time, 3 = More than half of the time, 4 = Most of the time, and 5 = All of the time). We utilized a Chinese version of the WHO-5 which demonstrated strong internal consistency in the current study (Cronbach's $\alpha > 0.9$).

2.2.5 Loneliness

In this study, we assessed loneliness using the UCLA Loneliness Scale-8 (ULS-8). This scale comprises eight items designed to measure the extent to which individuals experience loneliness and social isolation. Participants were asked to rate the frequency of specific thoughts and emotions related to loneliness over the past 2 weeks, using a 4-point Likert scale (0 = Never, 1 = Rarely, 2 = Sometimes, 3 = Often). We utilized a Chinese version of the ULS-8 which demonstrated acceptable internal consistency in the current study (Cronbach's $\alpha = 0.73$).

2.2.6 Insomnia

In this study, we assessed life insomnia using the Insomnia Severity Index-7 (ISI-7). This questionnaire consists of seven self-report items, each addressing a specific aspect of insomnia symptoms. Participants were asked to rate the severity of each symptom over the past 2 weeks, with scores ranging from 0 to 4 (0 = No problem, 1 = Mild, 2 = Moderate, 3 = Severe, and 4 = Very severe). We utilized a Chinese version of the ISI-7 which demonstrated strong internal consistency in the current study (Cronbach's $\alpha > 0.9$).

2.2.7 Physical activity

Physical activity was evaluated via frequency (31), and the questions were as follows:

"In the last month, how often did you engage in physical activity each week?" A 7-point Likert scale was used to collect answers, where 1 = never, 7 = almost every day.

2.2.8 Douyin usage at bedtime

Douyin usage at bedtime was evaluated via frequency and duration of the event (32), and the questions were as follows:

Frequency: "In the last month, how often did you use Douyin at bedtime each week?" A 7-point Likert was used to collect answers, where 1 = never, 7 = almost every day.

Duration: "How long do you typically use Douyin at bedtime each day?" Answers were collected in 7 categories: 1 = less than 15 min, 2 = 15 to 30 min, 3 = 30 to 45 min, 4 = 45 to 60 min, 5 = 60 to 75 min, 6 = 75 to 90 min, and 7 = more than 90 min.

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2.3 Statistical analysis

Given the nonnormal data, Spearman's rank-order correlation was used to probe for general correlations between variables.

Structural equation modeling (SEM) was employed to examine the hypothesized directional paths in the conceptual frameworks. According to Bagozzi and Yi (33), our sample size of 3,392 exceeded the recommended size of twice the number of model parameters ($n = 9$).

Variance Inflation Factor (VIF) values smaller than 5.0 were considered evidence of the absence of multicollinearity (34). Based on this rule, no multicollinearity was observed among the independent variables (VIF < 3.0).

Given our sample size and the presence of multivariate non-normality, we used an asymptotically distribution-free (ADF)/weighted least squares (WLS) estimator for analysis (35, 36). The bootstrap method with 10,000 replications was used to generate corresponding standard errors and confidence intervals for all paths (37–39).

Based on the ADF/WLS estimator, the goodness of fit was assessed using the following indices (36, 40): standardized root mean square residual (SRMR) < 0.08; Tucker–Lewis index (TLI) > 0.95; goodness-of-fit index (CFI) > 0.95, and root mean square error of approximation (RMSEA) < 0.05. We did not employ the $\chi 2$ test because it is strongly affected by sample size and violation of the multivariate normality assumption (41–43).

Factor loadings for latent variables in the conceptual model >0.5 were considered acceptable. An indirect effect (i.e., a product of coefficients for the constituent links) that significantly exceeded zero was evidence of mediation (44, 45).

All statistical analyses were conducted using SPSS 26.0 and AMOS 23.0 software (SPSS Inc., Chicago, IL, United States).

3 Results

3.1 Characteristics of respondents

The final analysis included a total of 3,392 eligible respondents, with 73.53% were males and 26.47% were females (Table 1). Approximately 78.86% of the respondents fell within the age range of 18 to 30 years old. Only one respondent reported not using Douyin at night, and only 18.99% of respondents stated that they did not use Douyin at bedtime. According to the 2022 Ultimate Guide to China Social Media, as of September 2021, the largest proportion of monthly active users on Douyin falls within the age range of 25–34 years old, which aligns with the characteristics of our sample (46). However, it is important to note that this guide reports a balanced gender distribution (53% male and 47% female) (46). In contrast, our sample does not exhibit a balanced gender distribution, indicating that it may not entirely represent Chinese Douyin users.

3.2 Correlations between variables

According to Figure 2, the frequency and duration of Douyin usage at bedtime were significantly correlated with insomnia,

TABLE 1 Respondent characteristics.

Variable	Category	n	Percentage
Gender	Male	n = 2,494	73.53%
	Female	n = 898	26.47%
Age (year)			
	18 ~ 30	n = 2,675	78.86%
	31 ~ 59	n = 710	20.09%
	>60	n = 7	0.01%
Frequency of physical activity			
	Never	n = 431	12.71%
	Rarely	n = 804	23.70%
	Occasionally	n = 894	26.36%
	Sometimes	n = 586	17.28%
	Often	n = 297	8.76%
	Very often	n = 111	3.27%
	Almost every day	n = 269	7.91%
Using Douyin at night			
	None	n = 1	0.00%
	Yes	n = 3,391	100.00%
Frequency of Douyin usage at bedtime			
	Never	n = 644	18.99%
	Rarely	n = 838	24.71%
	Occasionally	n = 813	23.97%
	Sometimes	n = 466	13.74%
	Often	n = 184	5.42%
	Very often	n = 70	2.06%
	Almost every day	n = 377	11.11%
Duration of Douyin usage at bedtime (minutes)			
	0 ~ 15	n = 842	24.82%
	16 ~ 30	n = 903	26.62%
	31 ~ 45	n = 878	25.88%
	46 ~ 60	n = 432	12.74%
	61 ~ 75	n = 195	5.75%
	76 ~ 90	n = 50	1.47%
	>90	n = 92	2.71%
		Mean	SD
Insomnia (ISI-7)		6.61	5.43
Life satisfaction (SWLS-5)		27.52	6.14
Well-being (WHO-5)		20.05	5.75
Depression (PHQ-9)		16.88	6.12
Anxiety (GAD-7)		6.48	4.72
Loneliness (ULS-8)		18.20	4.30

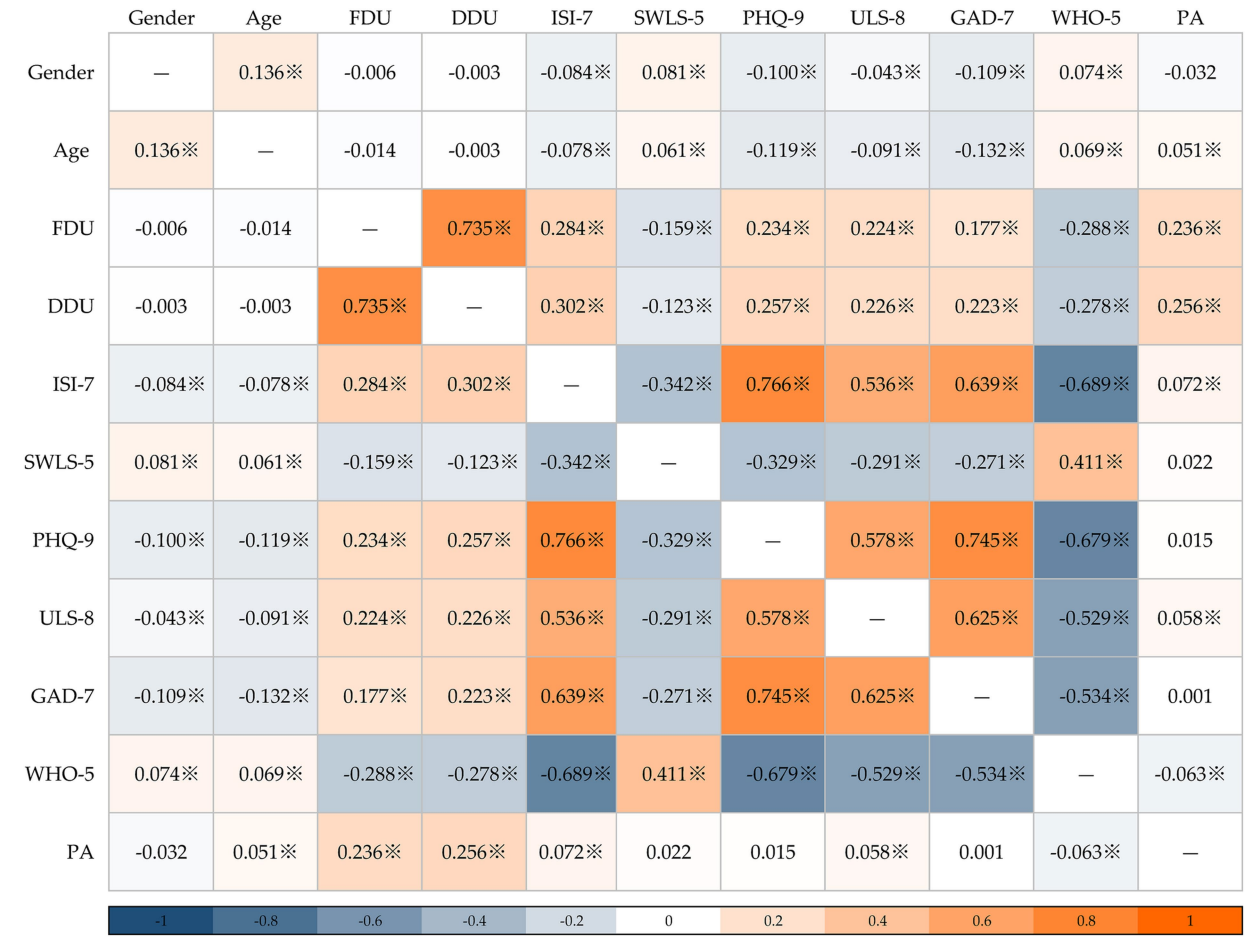

FIGURE 2
Correlation heatmap (※, $p < 0.05$; FDU, frequency of Douyin usage at bedtime; DDU; duration of Douyin usage at bedtime; PA, physical activity).

depression, anxiety, loneliness, well-being, life satisfaction, and physical activity. Moreover, insomnia was significantly correlated with gender, age, depression, anxiety, loneliness, well-being, life satisfaction, and physical activity.

3.3 Results of the SEM analysis

3.3.1 Model modification and factor loading

According to Figure 3, all six models showed good model fit (SRMR <0.08, TLI > 0.95, CFI > 0.95, and RMSEA <0.05). In addition, the factor loadings for latent variables are within an acceptable range (factor loading >0.5).

3.3.2 Direct effect, indirect effect, and total effect

3.3.2.1 Depression

According to Figure 3 and Table 2, depression was directly associated with increased Douyin usage at bedtime ($\beta = 0.08$; $p < 0.05$), and an indirect association via insomnia was also observed ($\beta = 0.18$; $p < 0.05$). In this model, the mediation proportion amounted to 69% of the total effect.

3.3.2.2 Anxiety

According to Figure 3 and Table 2, anxiety was directly associated with increased Douyin usage at bedtime ($\beta = 0.06$; $p < 0.05$), and an indirect association mediated by insomnia was also observed ($\beta = 0.16$; $p < 0.05$). In this model, the mediation proportion amounted to 72% of the total effect.

3.3.2.3 Life satisfaction

According to Figure 3 and Table 2, life satisfaction was directly associated with decreased Douyin usage at bedtime ($\beta = -0.05$; $p < 0.05$), and it was also indirectly associated with lower Douyin usage at bedtime via insomnia ($\beta = -0.09$; $p < 0.05$). In this model, the mediation proportion amounted to 69% of the total effect.

3.3.2.4 Well-being

According to Figure 3 and Table 2, well-being was directly associated with decreased Douyin usage at bedtime ($\beta = -0.20$; $p < 0.05$), and it was also indirectly associated with lower Douyin usage at bedtime via insomnia ($\beta = -0.11$; $p < 0.05$). In this model, the mediation proportion amounted to 35% of the total effect.

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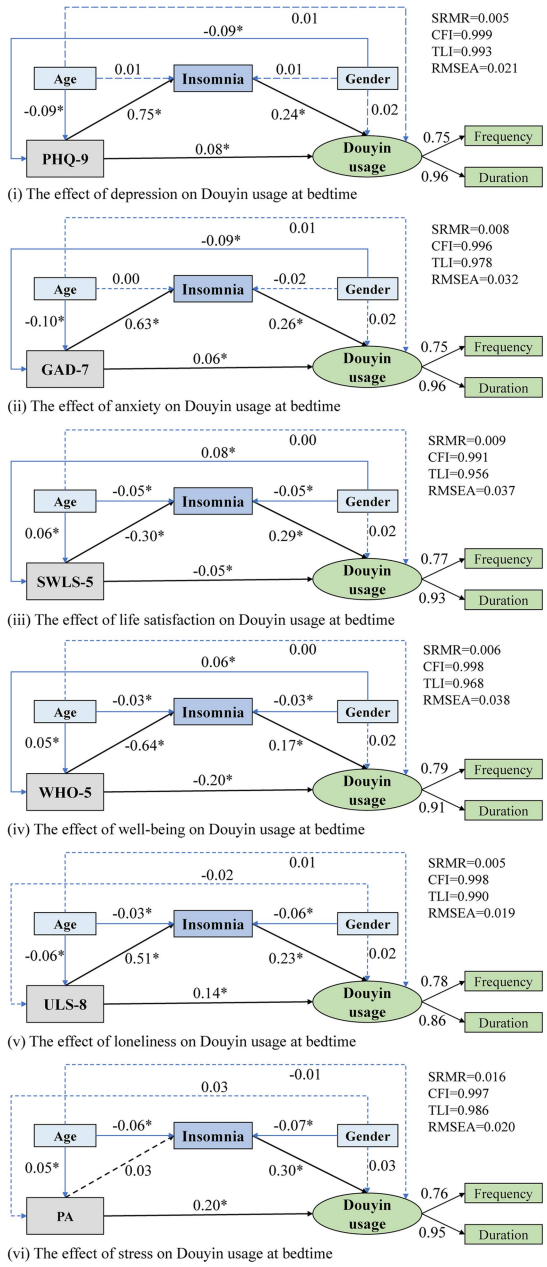

FIGURE 3
Results of path analysis and model fitting.

TABLE 2 The total and indirect effect of the SEM analysis.

Pathway	β (95% CI)	*p*
Total effect		
Depression → Douyin usage at bedtime	0.26 (0.23 to 0.30)	< 0.05
Anxiety → Douyin usage at bedtime	0.22 (0.19 to 0.26)	< 0.05
Life Satisfaction → Douyin usage at bedtime	−0.13 (−0.17 to-0.09)	< 0.05
Well-Being → Douyin usage at bedtime	−0.31 (−0.35 to 0.27)	< 0.05
Loneliness → Douyin usage at bedtime	0.26 (0.22 to 0.30)	< 0.05
Physical activity→ Douyin usage at bedtime	0.21 (0.16 to 0.25)	< 0.05
Indirect effect		
Depression → Insomnia → Douyin usage at bedtime	0.18 (0.13 to 0.23)	< 0.05
Anxiety → Insomnia → Douyin usage at bedtime	0.16 (0.13 to 0.20)	< 0.05
Life Satisfaction → Insomnia → Douyin usage at bedtime	−0.09 (−0.10 to-0.07)	< 0.05
Well-Being → Insomnia → Douyin usage at bedtime	−0.11 (−0.15 to-0.08)	< 0.05
Loneliness → Insomnia → Douyin usage at bedtime	0.12 (0.09 to 0.14)	< 0.05
Physical activity → Insomnia → Douyin usage at bedtime	0.01 (−0.00 to 0.02)	= 0.16

3.3.2.5 Loneliness

According to Figure 3 and Table 2, loneliness was directly associated with increased Douyin usage at bedtime ($\beta = 0.14$; $p < 0.05$), and it was also indirectly associated with lower Douyin usage at bedtime via insomnia ($\beta = 0.12$; $p < 0.05$). In this model, the mediation proportion amounted to 46% of the total effect.

3.3.2.6 Physical activity

According to Figure 3 and Table 2, physical activity was directly associated with increased Douyin usage at bedtime ($\beta = 0.20$; $p < 0.05$), while no substantial indirect effect was observed.

4 Discussion

Douyin usage at bedtime is a common behavior among Douyin users. A previous study revealed that approximately 98% of Douyin users will use Douyin at night, in which approximately 86% of Douyin users occupy their bedtime using Douyin (6). In the current study, we found that this behavior remains prevalent, with approximately 82% of users reporting Douyin usage at bedtime. However, there is limited evidence regarding the reasons why people choose to use Douyin at bedtime, despite increasing interest from researchers (4). To bridge this gap, we conducted the present study to explore the potential factors and mechanisms that drive Douyin usage at bedtime. Our findings demonstrate the significance of depression, anxiety, loneliness, and physical activity as important factors contributing to Douyin usage at bedtime, while life satisfaction and well-being act as inhibitory factors that might mitigate such usage.

4.1 Depression and anxiety

Depression and anxiety are common mental health problems that are usually associated with problematic smartphone usage and social media usage (47, 48). In this regard, Maguire and Pellosmaa (49) discovered that individuals with more severe mental health problems tend to Douyin addiction. To further clarify the impact of mental health on domain-specific Douyin usage behaviors and the potential mechanisms involved, we conducted the current study. Our findings

indicate that depression ($\beta = 0.08$; $p < 0.05$) and anxiety ($\beta = 0.06$; $p < 0.05$) may directly lead to increased Douyin usage at bedtime. Additionally, depression ($\beta = 0.18$; $p < 0.05$) and anxiety ($\beta = 0.16$; $p < 0.05$) may exert an indirect influence on Douyin usage at bedtime through the mediating role of insomnia. Notably, the indirect pathway is more prominent, accounting for approximately 69 to 72% of the total effect. A similar finding was also observed in the previous study by Zhang et al. (6), where depression and anxiety directly were associated with problematic Douyin usage at bedtime. One possible explanation is that individuals may turn to Douyin as a tool to alleviate their adverse mental health conditions and insomnia induced by these conditions, highlighting the potential positive aspects of Douyin usage. A recent case study by (50) partially supports this speculation. Their tracking survey revealed a negative relationship between social media usage at bedtime and the time to fall asleep, potentially indicating an improvement in insomnia.

It is worth noting that our findings suggest that males and young Douyin users may experience more severe depression and anxiety. This result is similar to previous research based on non-Douyin users. For instance, a study by Krokstad et al. (51) on the changing trends in mental health over the past three decades among Norwegians revealed that young individuals tend to exhibit poorer mental health. Additionally, a cross-sectional study by Kaneko and Motohashi (52) also discovered that males had worse mental health. In the context of our model, these findings imply that males and young Douyin users may exhibit increased insomnia symptoms and a greater reliance on Douyin.

4.2 Life satisfaction and well-being

Our findings indicate that life satisfaction ($\beta = -0.05$; $p < 0.05$) and well-being ($\beta = -0.20$; $p < 0.05$) may be directly associated with Douyin usage at bedtime, suggesting that they may act as potential protective factors against excessive Douyin use at night. Our findings are partly supported by previous studies focused on traditional social media. For example, Research by Sahin (53) and Geraee et al. (54) revealed a negative correlation between life satisfaction and social media addiction. Brooks (55) also observed a similar relationship between well-being and social media usage. These findings imply that excessive social media usage, including Douyin usage at bedtime, could potentially benefit from an improved overall state of physical and mental health.

As mentioned above, many studies have investigated the relationship between social media usage and life satisfaction, as well as well-being (53–55). Meanwhile, the connection between insomnia and life satisfaction, as well as well-being has also been uncovered (20, 56). However, less is known about the mediating role of insomnia between these factors. In response, we conducted the current study to address this gap. Our findings suggest that life satisfaction ($\beta = -0.09$; $p < 0.05$) and well-being ($\beta = -0.11$; $p < 0.05$) may improve Douyin usage at bedtime via alleviating insomnia. It is worth noting that our study found that life satisfaction was primarily linked to Douyin usage through an indirect pathway (approximately 69% mediation proportion), while well-being was primarily linked to Douyin usage through a direct pathway (approximately 35% mediation proportion). The reasons for this discrepancy remain unclear. Furthermore, our results indicate that females and older Douyin users tend to have higher levels of life satisfaction and well-being, implying better overall health status and reduced reliance on Douyin.

4.3 Loneliness

In the past decade, loneliness has been considered one of the major factors contributing to internet addiction and problematic social media usage (13, 57). In this aspect, several studies have explored the association between loneliness and Douyin usage, finding a positive relationship between them (58, 59). However, there is limited knowledge about the specific mechanisms through which loneliness influences Douyin usage. To bridge this gap, our study investigated the effect of loneliness on Douyin usage at bedtime and the potential mediating role of insomnia. Our study found that loneliness ($\beta = 0.14$; $p < 0.05$) may directly contribute to increased Douyin usage at bedtime. Moreover, insomnia ($\beta = 0.12$; $p < 0.05$) appears to play a significant mediating role in this relationship. Interestingly, in this mediation model, the direct and indirect effects are almost equal, with the mediation accounting for approximately 46% of the total effect. In conclusion, both loneliness and loneliness-induced insomnia may drive Douyin users to use Douyin at bedtime.

Furthermore, in line with previous research involving the general public, males and young individuals might experience higher levels of loneliness (60, 61). Our findings indicate that male and young Douyin users may have higher levels of loneliness than their counterparts, which implies that they may have stronger motivations for using Douyin at bedtime.

4.4 Physical activity

Regular physical activity has long been regarded as an effective strategy for improving both physical and mental health (62, 63). Some researchers also believe that regular exercise has a positive impact on alleviating internet and social media addiction (64, 65). However, our findings indicate that physical activity ($\beta = 0.20$; $p < 0.05$) was directly associated with increased Douyin usage at bedtime. Moreover, no significant indirect effect was observed in our model ($p < 0.05$), which means physical activity may not impact Douyin usage at bedtime via insomnia. The reasons behind this finding may be related to the specific population we included. In the current study, we included active Douyin users who have used Douyin at least 1 h per day in the past month. In this context, a recent study found that physical activity was more effective in improving social media usage among individuals with low levels of social media addiction (66). However, among those with high levels of social media addiction, physical activity may act as a catalyst for increasing social media usage (66). To better understand the role of physical activity in improving Douyin usage at bedtime, we recommend that future research conducts a comparative or stratified analysis based on Douyin addiction levels. This could provide valuable insights into the complex relationship between physical activity and Douyin usage.

4.5 Limitations

Some limitations should be noted when interpreting our findings. First, our study had an unbalanced gender distribution, with 78.86% being male. This may not accurately reflect Chinese Douyin users. Therefore, our findings may not be entirely applicable to Chinese

Douyin users. Second, our study only included Douyin users who used Douyin for at least 1 h per day in the past month. Therefore, our findings cannot be generalized to the general public. Third, our study used a chain referral method to obtain data, which may result in self-selection bias. This is because participants may be influenced by those who have already participated in the study. Fourth, we only used self-reported measures due to our limited experimental conditions, so reporting bias must have existed. Some variables, such as the duration of Douyin usage at bedtime, can be re-investigated with objective measures. Finally, our study used a cross-sectional design, which limits our ability to establish causal relationships between variables. This is an inherent limitation of analyzing such data. To re-examine the causality in each path, longitudinal trials or controlled trials are warranted.

5 Conclusion

This study aimed to investigate the factors driving Douyin usage at bedtime and explore potential mechanisms. Our results revealed that high levels of depression, anxiety, loneliness, and low levels of life satisfaction and happiness may drive people to use Douyin at bedtime. Insomnia appears to be a significant mediator between the factors of interest and Douyin usage at bedtime. One possible explanation is that Douyin users might turn to Douyin as a tool to alleviate their adverse physical and mental health conditions. Additionally, we found that engaging in physical activity did not improve Douyin usage; in fact, it might lead to increased usage. The specific reasons for this require further exploration. In summary, our findings offer a unique perspective on why Douyin users are drawn to using Douyin at bedtime.

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 humans were approved by the Ethics Review Board of Southwest University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SS: Writing – original draft, Writing – review & editing. HL: Writing – review & editing. SF: Writing – review & editing. RP: Writing – review & editing. XZ: Writing – original draft, Writing – review & editing. HL: Writing – review & editing, Investigation. MZ: Writing – review & editing. MY: Writing – review & editing.

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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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A mixed methods analysis of existing assessment and evaluation tools (AETs) for mental health applications

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Introduction: Mental health Applications (MH Apps) can potentially improve access to high-quality mental health care. However, the recent rapid expansion of MH Apps has created growing concern regarding their safety and effectiveness, leading to the development of AETs (Assessment and Evaluation Tools) to help guide users. This article provides a critical, mixed methods analysis of existing AETs for MH Apps by reviewing the criteria used to evaluate MH Apps and assessing their effectiveness as evaluation tools.

Methods: To identify relevant AETs, gray and scholarly literature were located through stakeholder consultation, Internet searching via Google and a literature search of bibliographic databases Medline, APA PsycInfo, and LISTA. Materials in English that provided a tool or method to evaluate MH Apps and were published from January 1, 2000, to January 26, 2021 were considered for inclusion.

Results: Thirteen relevant AETs targeted for MH Apps met the inclusion criteria. The qualitative analysis of AETs and their evaluation criteria revealed that despite purporting to focus on MH Apps, the included AETs did not contain criteria that made them more specific to MH Apps than general health applications. There appeared to be very little agreed-upon terminology in this field, and the focus of selection criteria in AETs is often IT-related, with a lesser focus on clinical issues, equity, and scientific evidence. The quality of AETs was quantitatively assessed using the AGREE II, a standardized tool for evaluating assessment guidelines. Three out of 13 AETs were deemed 'recommended' using the AGREE II.

Discussion: There is a need for further improvements to existing AETs. To realize the full potential of MH Apps and reduce stakeholders' concerns, AETs must be developed within the current laws and governmental health policies, be specific to mental health, be feasible to implement and be supported by rigorous research methodology, medical education, and public awareness.

KEYWORDS

mobile apps, mental health, digital health, guidelines, evaluation

Introduction

The COVID-19 pandemic has created numerous mental health challenges for the global population, including uncertainty, stress, and isolation (1, 2). Social distancing and changes in practice around COVID-19 have forced healthcare providers worldwide to provide their services through online platforms, thus acting as a catalyst to raise awareness, interest, and uptake of mobile Health Applications (mHealth Apps) (3). mHealth Apps are software applications on mobile devices that process health-related data and can be used to maintain, improve, or manage an individual's health (4). Currently, the demand for mHealth Apps is high. A 2010 public survey found that 76% of 525 respondents would be interested in using their mobile phones for self-management and self-monitoring of mental health if the service were free (5). In a similar survey of physicians' attitudes toward mobile health (mHealth), most expressed hope that technology could be very effective in their clinical practice (6). Recently, some countries have introduced legislation and policies to promote telemedicine by easing restrictions before the COVID-19 pandemic (7, 8). These changes varied across the countries, ranging from a relaxation of regulations due to the pandemic and easing of restrictions on prescription medications, to telepsychiatry services being reimbursed at the same rate (or higher) than in-person consultations during the COVID-19 pandemic. However, no follow-up data is available on the current state of these changes and their impact (8).

The IQVIA Institute for Human Data Science estimated that more than 318,000 Health Apps were available in 2017 (9), with more than 10,000 Apps explicitly designed for mental or behavioral health (10). With the number of available mHealth Apps on the rise, so are the concerns regarding their effectiveness and safety. Given the rigorous assessment pharmaceuticals and medical devices must undergo to be licensed, there is an increasing call to apply the same rigor for mHealth Apps to ensure safe and effective implementation of state-of-the-art technology into healthcare (9). This is especially important for Mental health Applications (MH Apps), which hold the potential to improve access to high-quality mental health care.

There is insufficient evidence for the effectiveness of MH Apps, with one paper reporting that only 3.4% of MH Apps were included in research studies to justify their claims of effectiveness, with most of that research undertaken by those involved in developing the App (11). A team of researchers reviewed seven meta-analyses of MH Apps for the quality of available evidence with respect to the use of mental health applications and found that the studies were generally of lower quality and did not offer strong empirical support for the effectiveness of the Apps (12). The problem is further compounded by the observation that randomized controlled trials (RCTs) in this area rarely report the details of the MH App they are providing to research participants (13). Therefore, in order to improve the effectiveness of MH Apps, high-quality, evidence-based research must be conducted to evaluate them. This will allow for the development of standardized guidelines that can be used widely to objectively and regularly assess existing and future MH Apps.

Evidence-based guidelines that have been developed for mental health interventions (e.g., National Institute of Clinical Excellence in England and the APA in the United States) have generally not been applied to MH Apps, likely due to the significant differences in delivery mediums. Only minimal guidance is available on (a) the development and reporting of MH Apps, (b) their effects and side effects, (c) information on matters related to privacy and security, and (d) their scientific testing and reporting (14). Notably, the demand for mobile health App guidance and regulation has increased (15). The National Health Service (NHS) in England, for example, developed an *Apps Library*, which publishes lists of health applications reviewed using a standard set of criteria, including security and clinical safety, outcomes, value for money, focus on user needs, stability and simplicity of use and evidence base (16). The United States of America's Food and Drug Administration (FDA) provides regulatory oversight on Apps that function as medical devices and may pose risks to patients (17). Similarly, the European Commission (EC) has issued its own guidelines for app developers (18). In Germany, the DiGA (Digitale Gesundheitsanwendung or Digital Health Applications in English) is a set of health legislation and rules aimed allow digital healthcare applications to be prescribed by doctors, similar to the way medications are prescribed, for a variety of diagnoses including mental health conditions (19).

Clinicians, healthcare providers, policymakers, and members of the general public have identified a need for more specificity and coordination in making an informed decision when selecting an MH App (20). Care providers need more information on the skills and knowledge required to convey timely information and recommend safe and effective app use (21, 22). This need has led to the development of AETs (Assessment and Evaluation Tools) to help guide users. AETs can include frameworks, guidelines, rating systems, or App libraries that assess and/or evaluate a mobile health application, including MH Apps, for various criteria, such as privacy, clinical information, user experience and authenticity. This paper aims to provide a better understanding of the existing AETs for MH Apps and provide insights for service providers and for people with lived experiences with mental health problems. For health professionals, a better understanding of AETs can lead to the development of easy-to-use and evidence-based "prescribing guidelines." For MH App users, a greater understanding of AETs could ultimately result in easy-to-read product information regarding side effects, and relevant privacy, security, and quality issues. It is, therefore, important that AETs provide guidance to professionals as well as the general public in a manner that is easily understandable, such as providing both technical reports and lay-person summaries.

A literature review and qualitative analysis of existing assessment and evaluation tools for MH Apps was conducted to understand the existing standards and guidelines. To assess the strengths and limitations of existing AETs for MH Apps, the overall quality of AETs was quantitatively analyzed using the Appraisal of Guidelines for REsearch and Evaluation, version 2 (AGREE II). The AGREE II is a commonly used instrument to evaluate guidelines that identify best practices in guideline or framework development (23).

Abbreviations: ADAA, Anxiety and Depression Association of America; AET, assessment and evaluation tool; AGREE II, appraisal of guidelines for research and evaluation, version 2; APA, American Psychological Association; FDA, Food and Drug Association:; MH Apps, mental health applications; mHealth Apps, mobile health applications; MHCC, Mental Health Commission of Canada; NHS, National Health Service; RCT, randomized controlled trial.

Objectives

The primary objective of this study was a qualitative analysis of evaluation criteria of AETs and identifying the strengths and limitations of these tools. The secondary objective was to assess the existing AETs quantitatively against existing standards using the AGREE II tool.

Methods

We began with a synthesis of existing AETs using a broad scan of literature in the field in order to: (a) understand the context of AETs (e.g., information on AET developers, types of Apps to evaluate and intended user audience) (b) collect information on criteria used for evaluation and (c) identify resources, links, and gaps. In addition to Internet and literature searches (including a bibliography scan of available tools), we connected with knowledgeable stakeholders recommended by experts in the field through personal and professional networks. These stakeholders were mental health app developers ($n = 2$), mental health professionals ($n = 3$), mental health professionals with specific interest in evaluation and implementation of MH Apps ($n = 6$), framework developers ($n = 3$), mental health leaders (e.g., Chief or head of department; $n = 3$), mental health app user ($n = 1$), mental health policy makers (e.g., individuals who work with the government; $n = 3$) and mental health educators ($n = 2$) across Canada and abroad. A list of national and international stakeholders was constructed, and they guided an initial list of AETs.

We then conducted a narrative literature review (24) of AETs for mHealth and MH Apps and related publications. We reviewed AETs for both mobile health and mental health applications to encompass all available AETs for MH Apps. The following are the methods and results of the literature review.

Literature review

Search strategy

We identified AETs for mHealth and MH Apps using a three-pronged approach: (a) gathering tools via stakeholder feedback (providing recommendations of AETs to include in our review) and internet searching (Google and Google Scholar) (b) a focused literature search using bibliographic databases, and (c) a focused search of peer reviewed publications in this area.

The literature search for scholarly articles was conducted by a health sciences librarian (TR) who developed the search strategy with input from the research team. The strategy used database-specific subject headings and keywords in the following databases: Medline (including Epub ahead of print, in-process, and other non-indexed citations), APA PsycInfo, and Library, Information Science and Technology Abstracts (LISTA). The search strategy included terms for mobile and e-health applications (e.g., mobile health, mhealth, digital tools), terms for mental health applications (e.g., mental, e-mental, wellness) combined with terms for evaluative frameworks (e.g., evaluation, usability, best practice framework, guideline, standards), as well as names of commonly used frameworks already known to the research team. As they arose in the results, app rating scales were also included in the search if they were a part of a framework. The year range was from January 1, 2000 to January 26, 2021 (the date of search execution). The strategies were designed to favor specificity over sensitivity, as this was not intended to be a comprehensive systematic or scoping review. See Figure 1 for the MEDLINE search strategy.

Inclusion and exclusion criteria

Though not a systematic review, we engaged in a formal screening process using eligibility criteria to streamline our selection process. The inclusion criteria for the literature review were studies in English that provided a tool or method to evaluate MH Apps and were published from January 1, 2000, to January, 2021. Studies in a language other than English and studies on mobile applications unrelated to a mental health area were excluded.

Data extraction

The following data points were collected from each paper: author, organization affiliation, year of publication, name of the AET, country of origin, description of the framework, and the evaluation criteria of the AET.

Study selection

Once the duplicates (including multiple papers reporting on the same AET used in a different research context) had been removed, two researchers (CT and WK) reviewed the document titles and abstracts independently. Finally, three researchers (FN, CT, and WK) met to agree on the final list of documents. Titles unrelated to the topic, scientific and popular articles, news articles, books, presentations, and opinion pieces unrelated to AETs were excluded. Each researcher evaluated the documents against the inclusion criteria and screened the document's reference list for additional resources. Independent results were compared between the two researchers (CT and WK). When discrepancies existed, a third researcher (FN) was involved in resolving eligibility disagreements.

Methods of analyses

(1) Qualitative analysis of AET criteria.

We used the constant comparative method (CCM) to analyze the qualitative data and determination of themes (25, 26). This qualitative analysis method combines inductive coding with a simultaneous comparison of all attributes obtained from our data (26). Researchers applied open coding as a first step in the coding process (CT and WK) to identify attributes and allow categories of AET evaluation criteria to emerge from the data. In open coding and comparison, initial categories were changed, merged, and omitted when necessary. The second step involved axial coding to explore connections between categories and sub-categories. Selective coding as a third step involved selecting the core themes of AET evaluation. To better understand the technological terminology of the AETs, we consulted team members with expertise in Information Technology (IT).

Database: Ovid MEDLINE: Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE: Daily and Ovid MEDLINE: <1946-Present>

Search Strategy:

1	(mobile health or mhealth or m-health or MHapp*).ti,kf,hw.
2	((e-health or ehealth or e-mental or emental) adj5 (app or apps or application* or tool* or based or intervention* or program* or therap*)).ti,kf,hw.
3	((medical or health or wellness or mental*) adj2 (app or apps or mobile application*)).ti,kf,hw.
4	((medical or health or wellness or mental*) adj3 (website* or web)).ti,kf,hw.
5	((digital* or website* or web) adj2 (app or apps or application* or tool*)).ti,kf.hw.
6	((phone* or telephone* or smartphone* or cellphone* or smartwatch*) adj2 (app or apps or application* or tool*)).ti,kf,hw.
7	((evaluat* or evidence-based or quality or report* or privacy or Security or test or testing or valid* or prescri* or regulat* or trustworth* or usability or user experience* or apprais*) adj3 (framework* or guideline* or guidance or guide* or standard or standards or principle* or criteria or tool or tools or checklist* or checklist*)).ti,kf,hw.
8	(evaluat* adj3 (content* or quality or privacy or Security or valid* or trustworth* or usability)) .ti,kf,hw.
9	(assess* adj3 (framework* or guideline* or guidance or standard or standards)) .ti,kf,hw.
10	(best practi* adj3 (framework* or guideline* or guidance or standard or standards or principle* or criteria or tool or tools or checklist* or check list*)).ti,kf,hw.
14	Mobile App* Rating Scale.ti,kf,hw.
12	"System Usability Scale" .ti,kf,hw.
13	(mERA adj5 (checklist or check list)).ti,kf,hw.
14	(Assessment adj3 (checklist or check list)).ti,kf,hw.
15	1 or 2 or 3 or 4 or 5 or 6
16	7 or 8 or 9 or 10 or 11 or 12 or 13 or 14
17	15 and 16 (263)
18	Limit 17 to yr='2000 -Current" (234)

FIGURE 1
MEDLINE search strategy used for the literature review.

(2) Quantitative analysis: quality assessment of AETs using AGREE II Tool.

We used the AGREE II scale to assess the quality, methodological rigor, and transparency of each AET (23). The AGREE II provides an overall score to assess the methodological quality of guidelines and provide a level of recommendation (strongly recommend, weakly recommend or recommend) of use for clinical practitioners. The AGREE II includes the following domains to guide assessment of AETs: *Scope and Purpose* (i.e., the overall aim of the guideline, the specific health questions, and the target population); *Stakeholder Involvement* (i.e., the extent to which the guideline was developed by the appropriate stakeholders and represented the views of its intended users); *Rigor of Development* (i.e., the process used to gather and synthesize the evidence, the methods to formulate the recommendations and to update them); *Clarity of Presentation* (the language, structure, and format of the guideline); *Applicability* (the likely barriers and facilitators to implementation, strategies to improve uptake, and resource implications of applying the guideline); and *Editorial Independence* (the formulation of recommendations not being unduly biased with competing interests).

Twenty-three key items across six domains were scored on a Likert scale from one to seven, with one being strongly disagree and seven being strongly agree. The score for each domain was obtained by summing all scores of the individual items in each domain and then standardizing as follows: (obtained score - minimal possible score)/(maximal possible score - minimal possible score) (27, 28). While the AGREE II instrument does not provide a universal standard on how to interpret scores, we used commonly described criteria (27, 28) for overall assessment and recommendation of AET quality: *strongly recommended* if five to six principal domain scores were $\geq$ 50%; *recommended* if three to four domain scores were $\geq$ 50%; *weakly recommended* if one to two domain scores were $\geq$ 50%, and *not recommended* if all scores were below 50%.

Results

Our three-pronged search identified 599 citations of potentially relevant titles and abstracts from the academic research literature. An additional 30 literature sources were identified through other search methods (including a Google and Google Scholar literature search).

Duplicate, non-applicable, and redundant records were removed, with 213 records remaining. A total of 155 literature sources were then excluded as they did not meet the inclusion criteria. The remaining papers ($n = 58$) were deemed eligible for inclusion based on their relevance to an AET. An additional 20 papers were deemed eligible from a review of reference lists ($n = 78$). Following a full-text review of these items, 65 items were excluded for the following reasons: 35 papers described general health AETs, 19 papers did not describe frameworks or guidelines that met the criteria of an AET, and 11 discussed AETs already identified in other included articles. Hence, 13 AETs (15, 21, 22, 29–38) met the inclusion criteria. See Figure 2 for an overview of the study selection process.

Overview of AETs

Table 1 describes the overall characteristics of the AETs. Of the 13 selected AETs, six (46%) were developed in Canada (21, 22, 29–32), five (38%) in the United States (33–37), one (8%) in England (15) and one (8%) in New Zealand (38). Five (38%) AETs were developed by

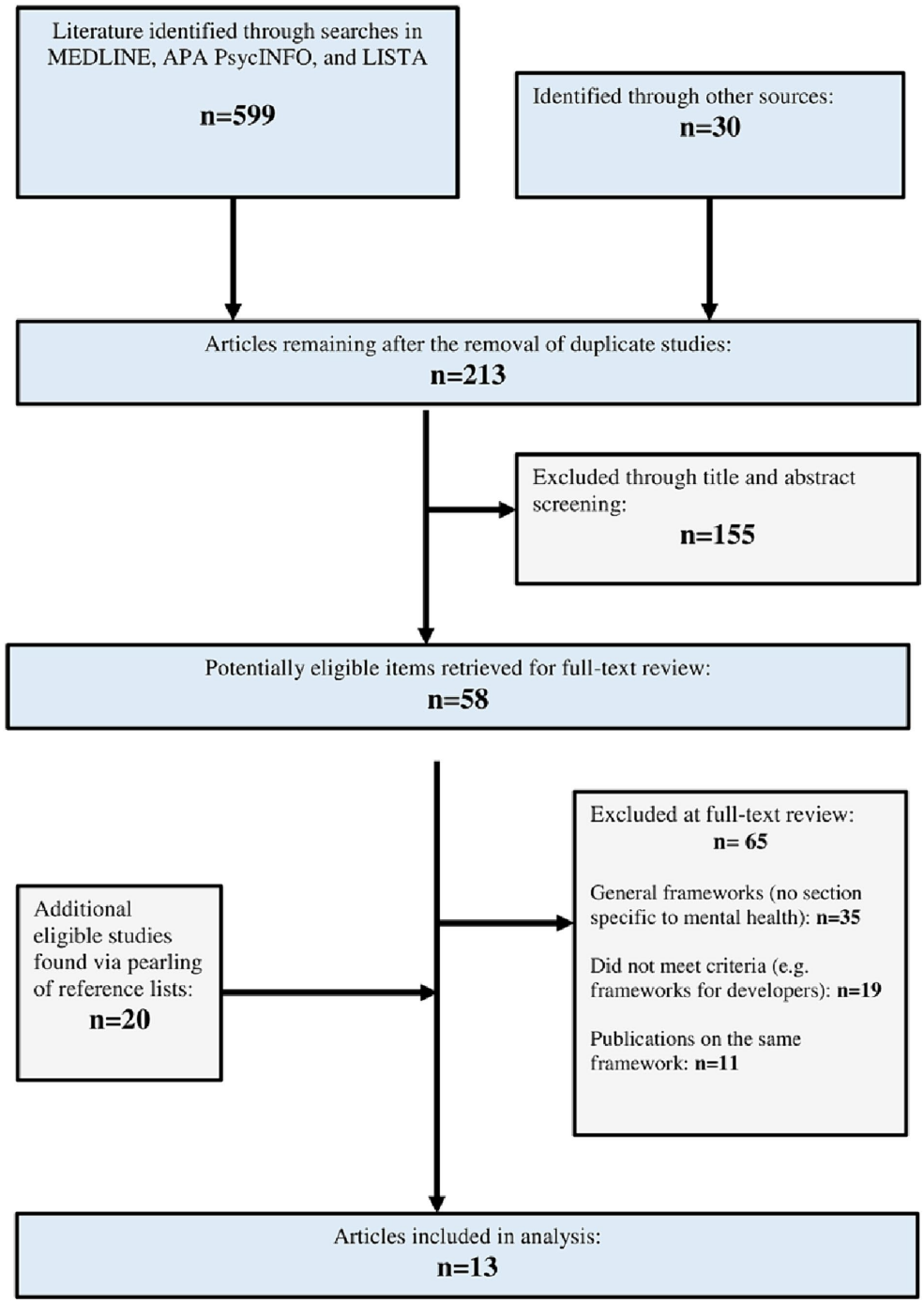

FIGURE 2
Overview of study selection process.

TABLE 1 Description of assessment and evaluation tools (AETs) for MH apps.

	Source affiliation	Country of origin	Intended audience	Area[a]	Type of eval. criteria[b]	Dev. details[c]	Type of tool	Implemented	Policy on update	Stakeholder engagement
Alberta Health Services (29)	Alberta Provincial Health Services	Canada	Clinicians, Researchers, App Developers	General	Selection criteria	No	App Directory	No	None	No
Strudwick (32)	CAMH (Hospital)	Canada	Health Care Providers (HCPs)	General	Questionnaire	Yes	Digital resources	No	None	No
Azad-Khanegah (21)	Individual PhD	Canada	HCPs, General Public	General	Rating scale	Yes	App rating index	No	None	Yes
MHCC (30)	Mental Health Commission of Canada (MHCC)	Canada	HCPs, Patients, App Developers	General	Selection criteria	Yes	Framework	Implement kit, but not implemented	None	Yes
Homewood (22)	Homewood (Non-profit organization)	Canada	HCPs	Youth	Selection criteria	Yes	Framework	No	None	Yes, limited details
Scarborough Health Network (31)	Scarborough Health Network	Canada	Patients	General	N/A	No	Mental Health App Library only	No	None	No
ADAA (33)	Anxiety and Depression Association of America (ADAA)	USA	Patients	General	Ratings key	No	Online library, Reviews	No	None	No
MindTools (34)	MindTools (Non-profit Organization)	USA	Patients and Clinicians	General	Rating scale	No	Online library	Yes, website	None	No
NHS, UK (15)	National Health Services (NHS) England	England	Patients, Service Providers	General	Selection criteria	No	Online library	Yes, website	None	No
One Mind (35)	Non-profit organization	USA	Professionals, Researchers, Patients	General	Rating scale	No	Online Library	Yes, website	None	No
Ranked Health (36)	Ranked Health (Non-profit organization)	USA	Providers and Patients	General	Rating scale	Yes	Online Library	Yes, website	None	No
APA (37)	American Psychiatric Association (APA)	USA	Clinicians and Patients	General	Hierarchical Selection criteria	Yes	Framework, Online Library	Yes, website	None	Yes, limited details
Health Navigator (38)	Non-profit organization	New Zealand	Patients	General	Selection criteria	No	Online Library	Yes, website	None	No

[a]Problem area and population. [b]Type of evaluation criteria. [c]Details of development.

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non-profit organizations (22, 34–36, 38), two (15%) by national professional organizations (33, 37), one by a local health service (29), another by a national health service (15), two by hospitals (31, 32), one by a national non-profit organization created by the government (30), and one by an individual as a Ph.D. (21) project. Three (23%) tools focused on general health Apps with dedicated sections on mental health (15, 36, 38), and the rest (77%) of the tools focused solely on MH Apps (21, 22, 29–35, 37). Three tools used the term *frameworks* (22, 30, 37), one used *app directory* (29), one used the term *app library* (31), and one used *app rating index* (21). The rest (54%) (15, 32–36, 38) were online libraries (i.e., websites) without a specific term to represent the AET.

These AETs used a variety of methods to assess app quality. Four (31%) AETs used rating scales (21, 34–36), one (8%) used a rating key (33), and another provided a questionnaire (32) to assess MH Apps. The rest (54%) of the tools used pre-selected criteria from which to assess app quality (15, 22, 29–31, 38). One tool offered a hierarchical selection criterion (37). Another AET assessed Apps in four stages: (a) internal review, (b) relevance to sponsoring country review, (c) clinical review, and (d) user review (38). Only two tools guided readers on how to use the selection criteria (22, 37). None of the AETs provided details on how the framework would be updated in the future (i.e., an updated policy).

We were able to find details on how these tools were developed (methodology) for only six (46%) of the AETs (21, 22, 30, 32, 36, 37). Limited information on stakeholder engagement in these AETs was available, with a noticeable absence of app distributors, app developers, and health funders. Even when an AET claimed to engage all stakeholders, little or no information was available on how these stakeholders were engaged. In terms of implementation, one of the AETs was associated with an implementation toolkit (30), and another AET is being used to guide an app-evaluating website (37).[1] Six AETs (46%) are a part of websites (15, 33–36, 38) that provide online guidance on applications using various selection criteria. No information on implementation was available for the remaining five (38%) AETs (21, 22, 29, 31, 32). Apart from the NHS *App Library* (15), none of these tools have been adopted by a health system at a national level. No information is available on the evaluation of their implementation. No data is available on how useful these AETs are in helping healthcare professionals and clients make informed choices. None of the AETs specified the population except one focused on youth (22). None of the AETs specified the problem areas (e.g., general well-being or a specific disorder). Similarly, no data is available on the number of MH App downloads or how these Apps are used.

The AETs in this environmental scan were included based on their stated focus on assessing and evaluating MH Apps. However, during analysis, our research team noted that these AETs are relatively non-specific to mental health issues and could be used as assessment and evaluation tools for general health applications. This observation has also been acknowledged by two of the AET developers (22, 37).

(1) Qualitative analysis of app assessment and evaluation criteria.

The research team (FN, WK, and CT) listed, then grouped, common themes across AETs to determine broad categories of AET criteria. Qualitative analysis of the 13 included AETs revealed seven themes: (a) *Authenticity of Content, Source and Process* (whether experts developed the content, whether users were involved in the development process and the app developer's background); (b) *Ethical and Legal Issues* (issues related to privacy and security, data sharing and data security); (c) *User Experience and User Engagement* (issues related to usability, user desirability, functionality, user engagement, customization, and personalization); (d) *Cost* (how much the app costs, in-app purchases); (e) *Clinical Use and Indications* (whether there are clearly described clinical indications); (f) *Risk to User* (whether there is a potential of harm caused by the App to the user); (g) *Technology-Related Issues* (whether the App provides technical information, and whether the app user has access to necessary equipment); and (h) *Evidence* (both scientific evidence and the number of downloads). Table 2 displays an overview of AETs assessed for the criteria mentioned above. At the same time, the themes often overlapped and a clear distinction between themes was not possible. Various sub-categories were identified and described under the major themes. These themes and sub-categories are displayed in Table 3 to indicate the variation and similarities of themes discussed in the 13 AETs.

Authenticity of content, process and source

This theme includes three sub-categories (a) *Authenticity of Content* (whether experts developed the content); (b) *Authenticity of the Process* (were users involved in the development process); and (c) *Authenticity of Source* (the app developer's background).

Ten (77%) (21, 22, 29, 30, 32, 34–38) AETs recommended *Authenticity of Content* or *Source* criteria. Of these, six (46%) (15, 21, 22, 30, 32, 37) considered the authenticity of the source (i.e., reliability of the app developer or third-party partnership). Four (31%) (15, 21, 22, 37) considered the authenticity of the content, most commonly using the term 'validity' (specifically, face validity) of the MH App content.

Most tools highlighted the importance of app developers' credibility (e.g., the type of business model used, source of funding, and transparency). AET developers used a variety of parameters and terms to describe authenticity criteria. For example, one AET (30) describes the criterion *Source Reliability* as consisting of developer and funding transparency. This tool also discussed user involvement in app development that consists of *User Inclusion, User Desirability and the Meaningful Inclusion of Users*. Another tool (34) considers third-party endorsements and the owner's credibility to be indicators of the source's authenticity.

Only three (23%) tools mentioned content as a criterion for evaluation. Only one tool (8%) (22) considered the cognitive and behavioral model from which the mental health application is derived as a criterion.

Ethical and legal issues

Nearly all the tools used ethical and legal standards as a criterion. Three sub-categories emerged under this theme: (a) *Privacy* (the safeguarding of user identity) and *Security* (the safeguarding of data); (b) *Data Management* (collecting, keeping, sharing, using or

1 https://Apps.Digitalpsych.Org/

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TABLE 2 Qualitative analysis of evaluation criteria for each assessment and evaluation tool.

	Authenticity-content, source & process	Evidence	User experience	Cost of the apps	Clinical use and indications	Risk to user	Ethical and legal	User engagement	Technology-related issues
Alberta Health Services (29)	Y	Y	N	N	N	N	N	N	N
Strudwick (32)	Y	Y	N	Y	Y	Y	Y	N	Y
Azad-Khanegah (21)	Y	Y	Y	Y	Y	Y	Y	N	N
MHCC (30)	Y	Y	Y	Y	Y	N	Y	Y	Y
Homewood (22)	Y	Y	Y	N	Y	Y	Y	Y	Y
Scarborough Health Network (31)	N	N	N	N	N	N	N	N	N
ADAA (33)	N	Y	Y	N	N	N	N	N	N
MindTools (34)	Y	Y	Y	N	N	N	Y	Y	Y
NHS, UK (15)	N	N	Y	N	N	Y	Y	N	Y
One Mind (35)	Y	Y	Y	N	Y	N	Y	N	N
Ranked Health (36)	Y	Y	Y	N	Y	N	Y	N	N
APA (37)	Y	Y	Y	Y	Y	Y	Y	N	Y
Health Navigator (38)	Y	N	Y	Y	N	N	Y	Y	Y

Y, yes, included; N, no, not included.

discarding data securely, efficiently, and cost-effectively); and (c) *Diversity and Equity* (diversity refers to the traits and characteristics that make people unique, while equity refers to providing everyone with the full range of opportunities and benefits).

Privacy and security concerns for the app user were included by 11 (85%) (15, 21, 22, 30, 32–38) of the tools. Of these, three (23%) (22, 30, 37) specified a specific assessment of whether a data collection policy was published, and two AETs (15%) (21, 22) assessed the extent of securing personal data collected. Ethical and legal concerns for the app user were assessed by seven (54%) (15, 21, 22, 32, 34, 35, 37) of the tools. Major app stores require a privacy policy before publishing an app (39). However, these policies have a broad focus. The complex legal language used in these policies might also make it difficult for people living with mental health problems and clinicians to comprehend the language.

Some of the AETs mentioned the need to consider user characteristics and *diversity, equity and cultural factors*. For example, one (30) AET explicitly highlighted the need for *gender responsiveness* (i.e., does the App consider the needs and preferences of men, women, boys, girls and gender-diverse people?). Two AETs highlighted the need for *cultural appropriateness* (i.e., how appropriate is the App for people from various cultures?) (22, 30). However, this emphasis did not reflect the focus audience or the selection criteria of our highlighted AETs. One AET (32) used language appropriateness as a selection criterion. Only one AET (22) included criteria that had special considerations for applying evaluation criteria for youth regarding privacy regulations, consent of minors, and personalization of content by age and culture. Two of the AETs (22, 33) used personalization as a selection criterion.

User experience and user engagement

Nine (69%) (15, 21, 22, 30, 33–36, 38) AETs used user experience as a criterion. Four (31%) (22, 30, 34, 38) used engagement as a criterion. Six (46%) (21, 22, 30, 32, 34, 37) AETs proposed the functionality of the App as selection criteria. In comparison, four (22, 30, 34, 37) assessed the quality of the user

TABLE 3 Summary of themes and criteria assessed by 13 assessment and evaluative tools.

	Themes and criteria
Alberta health services (29)	Expert opinion, Evidence (evidence from research), Source reliability (reliable developers)
Strudwick (32)	Ethical and legal (level of the consent), privacy, security and confidentiality, Risks (unintended consequences), Clinical use (benefits), reliability (accurate, and trustworthy), evidence (effective), Digital literacy (user skills in technology use), Access to technology, Cultural issues (Language barriers), Cost
Azad-Khanegah (21)	User interface (Esthetics), Cost (Affordability), Customizability, User experience (Ease of use, User engagement, Functionality,), Privacy & Security, Reliability (Trustworthiness), Clinical use (Usefulness) Evidence (link to scientific studies)
MHCC (30)	Evidence (effectiveness), Ethical and legal (Transparency of Information), Security, Information Security, User experience (Functionality, Usability), Source Reliability (Developer Transparency, Funding Transparency), User involvement in app development (user Inclusion, User Desirability, Meaningful Inclusion), Clinical use (Audience), Technical info (Supported Platforms, Interoperability), Cost (App Price)
Homewood (22)	Clinical use (Intended use and users), Source reliability (legal owner, funding), cost, Validity (Content review, face validity), Technical information (update cycle), User engagement (user input), behavioral model, User experience (prototype usability, Usability testing) Personalization, Legal and ethical (user consent, ethical principles, user data ownership and control, data sharing), Security & privacy, Technical information (technical requirements, interoperability), user engagement (user engagement, user feedback), Risk (no harm), Evidence (efficacy and dose-effect, effect size, effect over time, factor analysis, bias, sensitivity analysis, reproducibility)
Scarborough health network (31)	No criteria
ADAA (33)	User experience (Ease of Use, Interactive/feedback), Evidence (Effectiveness, Research), Personalization, Source reliability (Developer Identity, who are the developers?), Privacy (How private is your phone?), Validity (Content: What do MH apps claim to do?), Clinical use (Target Users-Who are the MH apps for?)
Mind tools (34)	User experience (usability, visual design, therapeutic alliance, strong advisory support,) User engagement (user engagement), Validity (content), Source Credibility (owner's credibility), Technical info (maintenance/frequency of updates), Source reliability (third-party endorsement), evidence of successful implementation, Privacy & Security, Legal and ethical (confidentiality, explanation of data journey, how data is used)
NHS, UK (15)	Risk (Clinical Safety), Security and privacy (Data protection), Functionality (Technical assurance, secure & stable), Technical info (Interoperability), User experience (Usability), Access to technology (Accessibility)
One mind (35)	Credibility, Evidence (research evidence), Rigor of development, Clinical use (clarity of purpose), User Experience, Security & Privacy Practices (Transparency) (data security, privacy policy)
Ranked health (36)	Evidence (Effectiveness, evidence-based) Clinical use (clinical relevance), credibility, Functionality, features, Legal and ethical (data sharing), Technical info (integration with other apps or medical), User experience (Usability, user interface, user experience), Access to technology (accessibility), Privacy & Security, Validity (Clinical foundation), User experience (Engagement style), Clinical use (Therapeutic Goal)
APA (37)	Background info (Business model, Credibility, Medical claims, Technical Costs and advertising Stability) Privacy and security (Data collected Data storage Deleting personal data Personal health information Security measures in place Privacy policy) Evidence based (First impressions, Impression after using, Clinical validity, User feedback supporting) Ease of use (Specificity to users and accessibility Short-term usability Long-term usability) Data integration (Data ownership access and export Clinically actionable Therapeutic alliance)
Health navigator (38)	Source reliability (Credibility, content quality, source quality), privacy & security, User experience (interactivity, appearance, fun & entertaining, ease of use), User engagement (stakeholder involvement, inclusive), Cost (cost consideration), Cultural issues (language), Access to tech (accessibility)

interface of the App (including the esthetics and ease of use), and one (38) used the criteria of how fun or engaging the App was for the user. Finally, five (38%) (21, 22, 30, 32, 37) AETs include criteria to evaluate whether user engagement was included in the development and maintenance of Apps. The most important sub-categories to clinicians, researchers and clients might be "user engagement," which is equivalent to "treatment adherence or compliance."

Evidence

Most AETs (21, 22, 29, 30, 32–37) considered evidence as a selection criterion using varied terminology and concepts. This theme can be divided into three categories: (a) *Empirical evidence*, (b) *Implementation Info*, and (c) *Cost-effectiveness*.

Ten (77%) (21, 22, 29, 30, 32–37) of the AETs suggested *evidence* as an app evaluation criterion. However, there is no consensus on what can be the evidence that an App is effective. While the terms evidence, evidence-based, and effectiveness were used by most (21, 22, 29, 30, 32–37) of these AETs, only one AET (22) described the concept in some detail. This AET proposed that evidence consists of efficacy and dose effect, effect size, the effect over time, factor analysis, bias, sensitivity analysis, and reproducibility. This AET also suggested how these parameters could be assessed. Another AET (37) considered a link to scientific studies as sufficient for evidence.

Cost-effectiveness, an essential parameter in selecting health interventions, can be understood as the trade-off between the MH

App's benefits and the App's cost (e.g., to the individual, to the clinician, or the overall healthcare system). Potential indirect benefits include improved physical health, enhanced current and future productivity, and reduced caregivers' demands (40). Currently, limited information is available on the cost-effectiveness of MH Apps. None of the AETs used cost-effectiveness as a selection criterion.

Clinical use and indications

Seven (54%) (21, 22, 30, 32, 35–37) AETs used clear descriptions of clinical indicators as a selection criterion. One AET (30), for example, considered clinical claims and target users to be an indicator of clinical use criteria. Health Apps exist on a spectrum, from consumer-facing, non-regulated, non-interventional Apps like fitness trackers to regulated, prescription-only Apps like digital therapeutic to manage substance use disorder (41). A wide variety of MH Apps are launched under the "well-being" categories rather than with specific "clinical indications." The issue becomes more complicated considering the legal applications; for example, it has been suggested that because most Apps are categorized as 'health and wellness' Apps, they are not designated as medical devices and thus fall outside the purview of the FDA guidelines. Those which may be medical Apps have utilized the regulatory discretion pathway to avoid scrutiny (42).

Risk(s) to the app user

MH Apps have the potential to cause significant risks and as such, governmental guidelines take a risk-based approach to evaluating mhealth Apps. Risks to Users can be considered under two categories: (i) *technology-related risks* and (ii) *clinical risks*. Five (38%) (21, 22, 30, 32, 37) of the AETs considered the risk to the users (potential of harm caused by the App). All AETs, however, focus on *technology-related risks* such as risks due to privacy, security or data-related issues. There is considerable overlap of the first category with privacy and security and data management under *ethical and legal issues*. There is sufficient evidence to indicate that not all health Apps are safe; based on traffic, content, and network analysis of health Apps reported that 79% of sampled Apps shared user data (43).

The issue of *clinical risks* has not received attention in AETs. Only one AET uses the term clinical safety (i.e., Is the App assessed to ensure that baseline clinical safety measures are in place and that organizations undertake clinical risk management activities to manage this risk?). Clinical risks can be further considered as (a) risks due to inaccurate health-related information (44); (b) increased risk of harm to self or others due to the App use (21); (c) smartphone addiction (45); and most significantly, (d) side effects of interventions that provide psychotherapy (46).

Cost of the apps

The cost of mental health services is a significant barrier to accessing care for people with mental health problems (47). The users must be aware of the *business model* to make an informed decision. Currently, health systems do not offer a system supporting the purchase of mhealth Apps. Only four of the AETs (31%) included the cost in their evaluation models. One AET assessed cost with a distinction between initial cost and ongoing (or in-app) purchases (32).

Technology-related issues

Three categories were identified in this theme (i) *Digital literacy* (skills related to the effective and appropriate use of technology), (ii) *Access to technology* and (iii) *Access to technical Info*. Seven (54%) (15, 22, 30, 32, 34, 37, 38) AETs considered at least one aspect of technology-related issues as their selection criteria. However, only one (32) AET listed user skills as a criterion in app selection. Five (38%) (15, 22, 30, 32, 37) AETs assessed the App's update cycle frequency, the degree of technology integration across platforms (including the number of supported platforms and interoperability), and minimum technical requirements for usage. Four (31%) (15, 21, 31, 36) AETs assessed issues of accessibility, with two AETs (30, 32) defining accessibility as the user's access to technology or digital literacy, and two AETs (22, 30) assessed the MH App's recognition of cultural issues for the user, such as a language barrier.

(2) Quantitative analysis: quality assessment of AETs using AGREE II tool.

Table 4 displays the core scoring domains for each of the 13 AETs on the AGREE II. To assess the quality, methodological rigor, and transparency of each AET, we used the AGREE II scale, a standardized tool for evaluating guidelines (23). On examination of independent assessment domains using prevalent acceptable criteria of a score greater than 50% (27, 28), we found that: seven (54% of total) AETs met the criteria on the first domain, *Scope and Purpose* (15, 21, 22, 29, 30, 36, 37); three (23%) AETs met the criteria on the domain *Stakeholder Involvement* (21, 30, 37); four (31%) tools met the criteria for *Rigor of Development* (21, 30, 32, 37); seven (54%) AETs met the criteria for *Clarity of Presentation* (22, 29, 33–35, 37, 38); and none (0%) of the tools met the criteria for *Applicability or Editorial Independence*. Using the criteria of 'number of domains with ≥50%' for overall assessment and recommendations, only three (23%) AETs met the criteria for 'recommended' (21, 30, 37), and one (8%) met the criteria for 'not recommended' (31), the rest (69%) were all within the 'weakly recommended' category (15, 22, 29, 32–36, 38).

Discussion

In this study, we conducted a qualitative and quantitative analysis of 13 Assessment and Evaluation Tools (AETs) for mental health applications (MH Apps) to identify the strengths and limitations of these tools, understand the existing evaluation criteria, along with assessing their overall quality. We qualitatively analyzed the evaluation criteria of these frameworks which revealed seven key themes: (a) *Authenticity of Content, Source and Process* (b) *Ethical and Legal Issues* (c) *User Experience and User Engagement* (d) *Cost* (e) *Clinical Use and Indications* (f) *Risk to User* (g) *Technology-Related Issues* and (h) *Evidence*. To quantitatively assess the quality, methodological rigor, and transparency of each AET, we used the AGREE II scale (22). We found that: seven AETs met the criteria on the first domain, *Scope and Purpose* (15, 21, 22, 29, 30, 36, 37); three AETs met the criteria on the domain *Stakeholder Involvement* (21, 30, 37); four tools met the criteria for *Rigor of Development* (21, 30, 32, 37); seven AETs met the

criteria for *Clarity of Presentation* (22, 29, 33–35, 37, 38); and none of the tools met the criteria for *Applicability or Editorial Independence*. When looking at the AETs overall, only three AETs met the criteria for 'recommended' to be used (21, 30, 37), nine were within the 'weakly recommended' category (15, 22, 29, 32–36, 38) and one met the criteria for 'not recommended' (31).

We found that there is a vast diversity in the terminology used of the AETs, as reported elsewhere (48). This lack of agreement may reflect a lack of consensus among IT professionals (48), which our review supports. Our qualitative analysis of evaluation criteria in AETs led to seven significant IT-related themes, with a lesser focus on clinical topics. While a few AETs mentioned clinical indicators and scrutinized clinical content, the emphasis did not reflect the importance of these areas. The content (i.e., clearly described theoretical background of interventions and assessments) is the primary factor distinguishing one MH App from another.

AETs, in general, did not evaluate *digital literacy* and *access to technology* in their app selection processes. Adequately addressing the *digital divide* is essential for broader implementation and system uptake of MH Apps and AETs. Evaluations of Apps with different, underserved demographic groups with diverse social determinants are needed. It is therefore not surprising that implementation remains the major problem with most AETs. Most AETs do not provide details on how to use the evaluation system and by whom. Without national policies, app developers are regulated by the app distributors such as Google and Apple (and their respective app stores). There is a noticeable absence of app distributors, app developers, health educators, and funders in developing AETs.

Similarly, significant variation exists in how AETs are developed and reported and their use of selection criteria. Most AETs lack rigor in development, and little information is made available on their evaluation and implementation, especially at the broader national health system level. Therefore, most of the AETs reviewed did not meet the criteria for recommendation when their overall quality was assessed using a rating tool (i.e., AGREE II). For example, some AETs consider the app developer or funder's characteristics, privacy policies, app features, performance characteristics, and ongoing maintenance or updating requirements, while others do not. Other areas of concern include a broad range in purpose and focus of AETs, limited information on stakeholder engagement during AET development, and exclusion or limited inclusion of equity-related issues such as gender, ethnicity, life span, and culture in selection criteria. Many AETs do not consider national or international policies, the resources available and context of health systems. The alignment of international evaluation standards would allow us to compare results across countries and create synergistic international collaborations.

The rapid proliferation of MH Apps has also led to concerns about their use by vulnerable populations. The limited evidence base and the high variance of app quality (including safety concerns) require a consistent and transparent approach when assessing and evaluating their quality. Several forms of AETs, including frameworks, rating scales, and app rating websites, have been published to help raise app quality standards. While some agreement on the technical criteria is considered, these approaches also have significant differences. The aims, scope, purpose, target audiences, and assessment methods vary considerably among these tools. These early efforts are commendable and have paved the path for further developments in this area. However, there is considerable potential for improvement and a need for constant updates to the AETs to reflect the field's rapid changes. Evaluations also need to be done regularly with the new versions of the App to ensure that quality and safety are guaranteed in all subsequent versions of the App.

The field of AETs for MH Apps is full of complexities. For example, the NHS *Apps Library*, with Apps assessed against a defined set of criteria, was released but quickly rolled back due to public outcry following research that showed privacy and security gaps in a large proportion of the included Apps (49). Furthermore, it has been observed that every 2.9 days, a clinically relevant app for people living with depression becomes unavailable and deleted from app stores (50). Similarly, app stores require regular updates, making it challenging to keep track of a quickly evolving field (51). Many AETs rely upon expert consensus, which can be opaque and difficult to understand for both users and clinicians (42). There is also significant inconsistency in their outcomes. For example, a study of three different ranking systems (PsyberGuide, ORCHA, and MindTools.io) demonstrated a lack of correspondence in evaluating top Apps, indicating weak reliability (10). Evaluations need to show which version of the App was used and what evaluation methods were used. Further work needs to be done to replicate evaluation studies to ensure consistent results in the evaluations.

Tools to assess and evaluate MH Apps are intended to protect the consumer and benefit the creator(s) with guidelines to drive innovation and industry standards. Evaluations must be conducted with the intended users using clear, transparent, and reliable evaluation criteria. Guidelines for reliable evaluation methods need to be developed and more widely used.

Furthermore, there is a lack of interoperability between MH Apps, AETs, and healthcare providers. This could provide an enriching opportunity for continuous improvement of MH Apps and their evaluation based on data entry and engagement with healthcare teams. As such, we found that AETs do not consider culture, ethnicity, gender, language, and life span issues. Current research methods might not be able to address complexities in the field. Most RCTs reporting mHealth Apps do not provide details of the intervention, making the job of AET developers and assessors difficult. Replicability is the litmus test of science, and there is a need to update trial-reporting guidelines to consider these concerns. There is also a general lack of agreement surrounding terminology and definitions of assessment criteria that may have led to misinterpretations for qualitative purposes, even though expert opinion was sought. The replication of studies will create a deeper understanding of how the App performs with different users in diverse geographical regions.

When developed, evaluated and implemented using standardized guidelines, mental health applications (MH Apps) can play an essential part in the future of mental health care (5), making mental health support more accessible and reduce barriers to help-seeking (52). Innovative solutions to the self-management of mental health problems are particularly valuable, given that only a small fraction of people suffering from mood or anxiety problems seek help (53), and even when they want to seek help, support is not always easily accessible (54). Nonetheless, if MH Apps are not well-designed and the App developers do not consider the needs of consumers, MH Apps will not meet the intended expectations. One study of app user engagement of MH Apps reported that the medians of 15-day and 30-day retention rates for Apps were 3.9 and 3.3%, respectively (55). Evaluations of mobile MH Apps that do not have consistent usage and

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TABLE 4 Domain-scaled scores on AGREE II for each assessment and evaluation tool.

	Scope and purpose	Stakeholder involvement	Rigor of development	Clarity of presentation	Applicability	Editorial independence	Domains with >50%
Alberta Health Services (29)	66%	31%	15%	57%	6%	8%	2
Strudwick (32)	31%	33%	65%	33%	47%	22%	1
Azad-Khanegah (21)	96%	93%	74%	48%	46%	33%	3
MHCC (30)	89%	63%	65%	33%	47%	33%	3
Homewood (22)	96%	6%	45%	67%	26%	8%	2
Scarborough Health Network (31)	6%	15%	1%	6%	8%	0%	0
ADAA (33)	6%	17%	1%	59%	1%	11%	1
MindTools (34)	43%	43%	32%	63%	25%	0%	1
NHS, UK (15)	70%	25%	15%	11%	25%	0%	1
One Mind (35)	48%	19%	21%	52%	11%	8%	1
Ranked Health (36)	56%	37%	13%	19%	8%	0%	1
APA (37)	96%	74%	64%	59%	46%	28%	4
Health Navigator (38)	28%	4%	7%	57%	14%	0%	1

those with low engagement rates cannot be reliably evaluated for efficacy. It is, therefore, crucial to develop research methods that consider these low usage rates, because current methods like RCTs may accurately evaluate these applications in a way that reflects their overall quality. There is also an urgent need to develop guidelines for the clinicians who want to suggest an App or the end users who want to use an App.

The limitations of this study included our search strategy, which was constrained by time and resources available. For this reason, we did not use a comprehensive systematic approach in our search for AETs, which may have led to certain evaluation frameworks being missed. However, one of the strengths of this project was our consultation with stakeholders, including experts in the field of mHealth and MH Apps, that we included to ensure we did not miss any notable AETs. The mixed-methods nature of this project lent itself to a detailed qualitative and quantitative assessment of existing AETs for MH Apps. We used the qualitative approach to identify strengths and limitations of existing AETs and their evaluation criteria, coupled with a quantitative assessment of the quality of AETs and whether or not they were recommended by using a standardized, pre-existing tool (the AGREE II). This is the first project, to our knowledge, that has assessed frameworks for evaluating MH Apps.

Conclusion

A variety of Assessment and Evaluation Tools (AETs) have been developed to guide users of mental health applications (MH Apps). However, most of these AETs are not very specific to MH Apps and can be used to assess most health Apps. Notably, our qualitative analysis revealed that a limited number of AETs: included MH App content as a criterion for evaluation; discussed the need to consider user characteristics for personalization of use and diversity; considered the use of evidence-base or cost-effectiveness as a criterion; included information on clinical safety; or addressed issues of accessibility, including platform interoperability and users' digital literacy. Using the AGREE II criteria for overall assessment and recommendations, only three out of 13 AETs we reviewed met the criteria for 'recommended', whereas one met the criteria for 'not recommended', and the remaining AETs were all within the 'weakly recommended' category. There is also minimal agreed-upon terminology in this field, and the AETs reviewing generally lacked focus on clinical issues, equity-related issues and scientific evidence.

Future development of AETs should include criteria that assess cultural acceptability, gender and ethnic/racial diversity, language and lifespan of MH Apps. Additionally, AETs should focus on scientific evidence to assess the effectiveness of an App in a standardized

manner. AETs should also strive to reach a consensus surrounding terminology and definitions of assessment criteria to allow for ease of understanding across various MH App users. Importantly, interoperability, especially with healthcare providers, should be a focus of future AETs, to evaluate the technical aspects of data sharing required to improve the coordination of the care continuum and provide more sustainable, effective support for users.

With standardized development, evaluation and implementation guidelines, MH Apps can play an essential role in managing mental health concerns. In order to address stakeholder concerns, AETs should be developed within current laws and government health policies and be supported by evidence-based research methodology, medical education and public awareness. Without continuous and rigorous evaluation, MH Apps will not meet expectations or achieve their full potential to support individuals who need accessible mental health care.

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.

Author contributions

All the authors were involved in planning, writing up the application, execution of project and the write up. In addition, specific expertise involved SA being responsible for managing the project along with CT. CT and WK were involved in data collection, analysis and write up. AT and BA went through several drafts and were also involved in knowledge exchange activities. TR is a librarian and carried out library searches. KK, SW, and MA from the MHCC were involved throughout the project in its execution and implementation as well as the knowledge translation activities. KM, MOH, and MIH provided technical expertise in research methods. YQ provided guidance in IT-related issues. FN supervised every stage of the project and was the Principal Investigator. All authors contributed to the article and approved the submitted version.

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Conflict of interest

KK, SW, and MA were employed by the Mental Health Commission of Canada.

The remaining 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.2024.1196491/full#supplementary-material

SUPPLEMENTARY DATA SHEET 1
Rating scale AGREE II. Provides the rating scale used to evaluate AETs. Details provided on each domain and the associated items, with a 7-point likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree) to determine how well information meets standards of the item in question.

SUPPLEMENTARY TABLE 1
AGREE II domain checklist & scoring. Provides overview and description of AETs included. Qualitative analysis of themes and scoring breakdown of each AET on the AGREE II domains, and the overall and domain scoring for each AET is included.

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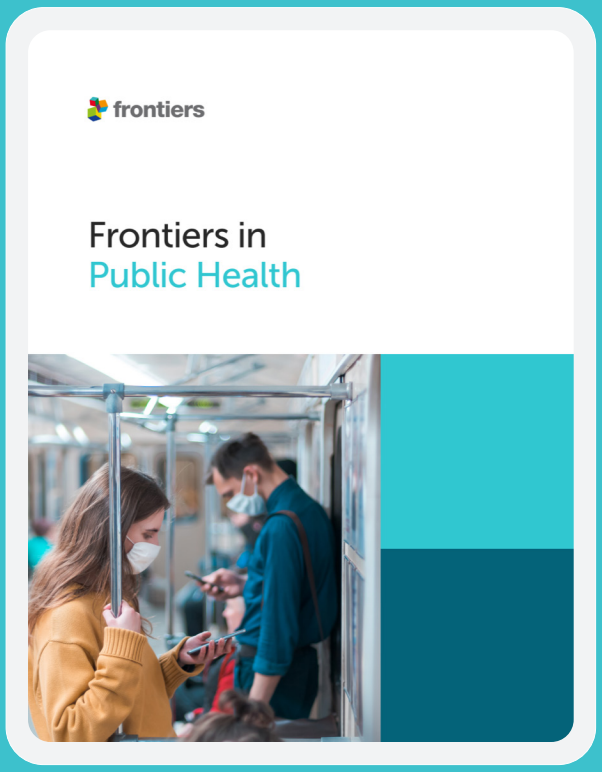

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