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Positive or negative? The effect of emerging technologies and products on mental health

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Positive or negative? The effect of emerging technologies and products on mental health

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Editorial: Positive or negative? The effect of emerging technologies and products on mental health

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Editorial on the Research Topic
Positive or negative? The effect of emerging technologies and products on mental health

In recent years, rapid advances in digital health technology, computing platforms, and the internet of things (IoT) have revolutionized the way we interact, communicate, and access information. These innovations have the potential to empower individuals and enhance societal wellbeing, as well as revolutionize healthcare delivery. However, they also bring new challenges, especially concerning their impact on mental health.

Numerous studies have explored the relationship between emerging technologies and mental health, leading to a dynamic and ongoing debate. Some research suggests that excessive use of social media may be associated with adverse mental health outcomes, including depression, anxiety, cyberbullying, and social isolation (1–3). There is particular concern about the potential negative effects of digital technology on mental wellbeing among adolescents and young adults (4). Conversely, other scholars argue that digital technology products can also be leveraged to address mental health issues in innovative and effective ways (5), and that they have great promise in providing timely, personalized, and accessible interventions for various mental health conditions (6).

In light of the pervasive presence of emerging technologies and their intricate interplay with mental health, further research is essential to harness their potential, while addressing potential mental health challenges emerging alongside the widespread integration of digital and electronic devices in contemporary society. Delving into the intricate relationship between emerging technologies and mental wellbeing holds significance beyond merely gauging potential advantages and drawbacks; it also serves as a foundation for crafting precise interventions and fostering psychological health.

To contribute to this vital area of research, this Research Topic presents a collection of nine articles that delve into the positive and negative effects of emerging technologies and products on mental health. These articles shed light on various aspects of the relationship between digital technology use and mental wellbeing.

Firstly, this Research Topic focuses on the potential mental health impacts of the most ubiquitous digital technology, the Internet. Nie et al. from University College London, investigated Internet use and rural-urban mental health inequalities in China. Their research provides valuable insights into the role of internet usage in shaping mental health disparities between urban and rural populations.

Subsequently, addressing potential negative experiences that may arise from internet usage, this Research Topic examined the relationship between cyberbullying, internet addiction, and mental health. A systematic review by Jeyagobi et al. from Malaysia examined the factors influencing negative cyber-bystander behavior and its association with mental health issues. Their research provides insights into bystander dynamics and the potential effects on mental wellbeing, shedding light on cyber-aggression's broader impact. Zhang et al. from Anhui, China explored the bidirectional association between smartphone addiction and depression among college students. Their findings underscore the need for comprehensive interventions addressing both smartphone addiction and depression to improve mental health outcomes.

As one of the most crucial products of the digital era, the influence of social media on mental health cannot be overlooked. Bonsaksen et al. from Norway conducted a study to illuminate the intricate link between adolescents' engagement with social media and their mental wellbeing. The findings underscore the critical role of understanding and mitigating negative digital experiences for safeguarding adolescent mental health in the age of pervasive social media engagement. Kim et al.'s study delved into COVID-19-related anxiety and the role of social media among Canadian youth. Their research highlights the interplay between social media usage and mental health during the pandemic, raising awareness of potential risks and benefits for youth mental wellbeing. Moreover, in a thought-provoking perspective article, Leightley et al. proposed a framework to maximize the positive and minimize the negative impact of social media data in studying youth mental health. With multidisciplinary perspectives from authors affiliated with various institutions, their work addresses the importance of secure data access while promoting mental health research in the digital age.

Following that, this Research Topic delved into the application and effectiveness of emerging technologies in the field of mental health treatment. Roncero et al. from Spain presented an original research study exploring healthcare professionals' perception of and satisfaction with mental health tele-medicine during the COVID-19 outbreak. Their work showcases the potential of telepsychiatry to improve mental health care accessibility and highlights its relevance in addressing mental health challenges during crises. Funnell et al. from Cambridge, United Kingdom investigated user feedback of a novel digital mental health assessment. Their study offers valuable insights into user experiences and preferences, contributing to the development of effective and user-friendly digital mental health interventions. In addition, research by Ho et al. from Hong Kong Polytechnic University and co-authors examined heart rate variability as a potential biomarker for hope, contributing to a deeper understanding of the digitization and visualization of mental wellbeing and its possible objective assessment using bio-indices.

By exploring these multifaceted dimensions of the topic, this Research Topic aims to deepen our understanding of how emerging technologies and products can impact mental health and provides valuable insights for researchers, clinicians, and policymakers in developing evidence-based interventions and promoting mental wellbeing in the digital age. The articles presented herein underscore the need for continued research, thoughtful policymaking, and responsible usage to strike a delicate balance between embracing technological progress and safeguarding our mental wellbeing.

Author contributions

CG: Conceptualization, Funding acquisition, Writing—original draft, Writing—review and editing. SG: Writing—original draft, Writing—review and editing. PS: Writing—review and editing. AF: Writing—review and 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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References

1. Hilty DM, Stubbe D, McKean AJ, Hoffman PE, Zalpuri I, Myint MT, et al. scoping review of social media in child, adolescents and young adults: research findings in depression, anxiety and other clinical challenges. *BJPsych Open.* (2023) 9:e152. doi: 10.1192/bjo.2023.523

2. Primack BA, Shensa A, Sidani JE, Whaite EO, Lin LY, Rosen D, et al. Social media use and perceived social isolation among young adults in the US. *Am J Prev Med.* (2017) 53:1–8. doi: 10.1016/j.amepre.2017.01.010

3. Kuss DJ, Griffiths MD. Social networking sites and addiction: ten lessons learned. *Int J Environ Res Public Health.* (2017) 14:311. doi: 10.3390/ijerph14030311

4. Orben A, Przybylski AK. The association between adolescent well-being and digital technology use. *Nat Hum Behav.* (2019) 3:173–82. doi: 10.1038/s41562-018-0506-1

5. Naslund JA, Aschbrenner KA, Marsch LA, Bartels SJ. The future of mental health care: peer-to-peer support and social media. *Epidemiol Psychiatr Sci.* (2016) 25:113–22. doi: 10.1017/S2045796015001067

6. Torous J, Roberts LW. Needed innovation in digital health and smartphone applications for mental health: transparency and trust. *JAMA Psychiatry.* (2017) 74:437–8. doi: 10.1001/jamapsychiatry.2017.0262

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Factors influencing negative cyber-bystander behavior: A systematic literature review

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Cyber-aggression is global epidemic affecting citizens of cyberspace, without regards to physical, geographical and time constraints. Recent research has identified the significant role of cyber-bystanders in exacerbating and de-escalating incidents on cyber-aggression they come across. Additionally, frequent exposure to cyber-aggression is found to have been associated with negative effects on participants of cyber-aggression, ranging from self-esteem problems to mental health disorders such as depression and anxiety, and in the worst cases even suicidal behaviors and ideation. Moreover, past research had also identified that negative bystanders could potentially become aggressors themselves. Therefore, the current review is aimed at uncovering the common themes and factors that drive individuals to resort to negative bystander behavior. Hence, a systematic literature review using the PRISMA framework was carried out, involving articles published between January 2012 to March 2022, on online databases such as SCOPUS, Science Direct, SAGE Journals, Web of Science, and Springer Link. Results obtained through the synthesis of 27 selected articles, were grouped into three categories, namely situational factors, personal factors and social influence. Upon further synthesis of the results, it was noted that many of the factors had interacted with each other. Thus, practical suggestion for prevention and future research would include addressing these interactions in preventative methodologies and research interests.

KEYWORDS

bystander intervention, systematic review, cyberaggression, cyberbullying, cyber-bystander

Introduction

The introduction of handheld supercomputers such as tablet computers and smartphones has not only made the internet and its affordances increasingly accessible but has also made one's exposure to cyberspace and the digital landscape as inevitable as it is essential. Aside from improving one's quality of life, the increased reliance and almost constant exposure to cyberspace can not only turn into dependence and subsequent addiction, but can also decrease one's quality of life in various aspects [e.g.,: (1–4)], including by exposing individuals to phenomena such as cyber-aggression (5, 6). According to past literature, rates at which cyber-aggression is perpetrated or victimizes an individual, fall between 1 to 41% and 3 to 72%, respectively (7).

Similarly to problematic internet use, it is associated with a host of negative thought patterns and behaviors ranging from mental health problems such as depression and suicide (8), to behavioral problems such as consequent or past involvement in bullying or aggressive behavior (8–11). Despite that, those who experience the fear of missing out (FOMO) tend to refrain from reporting the incident to others due to the fear of losing access to the internet or their phones which keep them connected in ways they desire (12), suggesting that the dependence on the digital world can potentially keep people in a loop of negative experiences.

Given the multifaceted nature of cyberaggression and the need to improve general understanding and intervention efforts associated with it, researchers from various fields have investigated the phenomenon from a variety of angles. These include identifying risk factors associated with cyber-aggressors (8, 10, 13), building standardizable research instruments [e.g.,: (11, 14, 15)], studying the efficacy of intervention strategies (16, 17), improving detection of aggression online (18–20), and more recently, cyber-bystander behavior, among others. The improved understanding of the role of cyber-bystanders in an incident of cyber-aggression has assisted in improving the understanding of the unique mechanism of cyber-aggression, and subsequently, the way it is defined, as well as the way intervention efforts are approached.

For instance, the presence and influence of cyber-bystanders are one of the reasons which prompted researchers to call for cyber-aggression to be distinguished from face-to-face aggression, defining it simply as being an act that is carried out using Information and Communications Technology (ICT), with the intent to cause harm to an individual (or individuals) who would have rather avoided it, omitting factors such as repetition and power imbalance which characterize traditional bullying or aggression (21, 22). This not only acknowledges the significant impact of other factors that mediate and exacerbate or merely influence cyber-aggression such as the presence and actions of cyber-bystanders but also allows for the inclusion of other singular but harmful acts such as happy slapping and outing (22, 23).

Cyber-bystanders, in simple terms, make up the audience who not only witness incidents of cyber-aggression but also have the capacity to either escalate or de-escalate the severity of the incident they have witnessed through their own response or even lack of response (21, 22). While many cyber-bystanders do utilize the opportunity to intervene positively and defend and/or comfort the victim, or even confront the aggressor constructively in order to de-escalate the situation, a non-negligible number of individuals engage in bystander behavior which reinforces the act of aggression against the victim or may even become hostile toward the aggressors (24). Moreover, cyber-bystanders are also at risk of becoming primary aggressors themselves (24).

Additionally, past research has identified that their impact on cyber-victims is no different than that of a primary aggressor. For instance, victims become warier of their social environment or experience fear and worry about being revictimized and having to revisit the incident and the pain it elicits whenever someone shows support for the aggressor by interacting with the victimizing post (12). Additionally, young people express that they do not receive the necessary support from their environment and admit to being unequipped to aid their peers manage and resolve these experiences (12). Hence, it is no wonder that feelings of loneliness, mistrust, embarrassment, fear, sadness and helplessness, and depressive symptoms as well as suicidal ideation, were associated with these revictimized individuals (25).

Furthermore, having to face incidents of cyber-aggression even as a bystander, was found to be associated with depression and/or anxiety due to the fear of being victimized, feeling empathic concern for the victimized individuals followed by the helplessness that results from not knowing how to navigate through the situation (26). In addition to that, frequent and long-term exposure to cyber-aggression on the internet could also result in individuals having lesser levels of empathic responses toward distressed individuals over time (27), and if bystanders were to perceive cyber-aggression as being a norm or expectation within their social circle, they are more likely to reinforce such acts (28).

Therein lies the importance of addressing what drives the behavior of bystanders, particularly those individuals who choose to engage in behavior that explicitly exacerbates a cyber-aggressive act, in addition to individuals whose passive behavior can act as silent approval of an instance of cyber-aggression. Therefore, the aim of the current review is to identify and synthesize results from past studies which have pinpointed the factors that influence an individual's decision to resort to negative bystander behavior. Additionally, the types and the frequencies of negative bystander behaviors addressed in the selected studies will also be highlighted for context and a better understanding of the phenomenon.

Methods

Identification of literature

Literature was sourced using five different online databases, namely Scopus, Science Direct, Web of Science, Springer Link, and SAGE Journals. The search was conducted during the last week of February 2022 up to mid-March 2022, targeting articles published in the past decade and throughout the search period.

Keywords to be used were identified by reviewing past literature addressing negative cyber-bystander behavior—words associated with the term "bystander" and the various forms of negative bystander behavior were sourced. The search resulted in the finding that cyber bystander was used interchangeably with the words "cyber observer" and "cyber witness", and the types of negative bystander behavior can be summarized as being behaviors that reinforce the aggressor or act of aggression, aggressive behaviors, or passivity. Additionally, before identifying the keyword string to be used, the search features of the selected online literature databases were investigated. Special symbols to promote truncation of used keywords were omitted as they were already built into the database search engines.

The final string of keywords used was "((cyber bystander) OR (cyber witness) OR (cyber observer)) AND (aggressive OR passive OR reinforce)", whereby the keyword string was divided into two halves, containing the synonyms of "cyber-bystander" in the first half and keywords associated with negative bystander behavior for specification and focus in the second half.

Eligibility and screening

Literature was screened in multiple stages, beginning from the inspection of the title and abstract to select suitable articles from the databases, followed by the close examination of the full-text of the article to determine whether they qualify to be included in the review. Inclusion and exclusion criteria were set as parameters to aid these processes, to ensure that a coherent set of articles are selected to be included in the review, allowing the researcher to fulfill the purpose of the study as accurately as possible.

Eligibility

Firstly, in order to ease the process of reviewing the articles, and to avoid misinterpretation of the contents of the articles due to flaws in translation, the articles screened were limited to those written in the English language. Secondly, a timeline spanning a decade, from 2012 to the current year, was set, taking into account the development of the technological scene which may have differed too vastly in the previous decade given how rapidly technology has evolved, possibly affecting the findings regarding individuals' behavior online. In addition to that, only research articles that discuss and elaborate on negative cyber-bystander behavior, which includes behaviors such as assisting the bully, aggressive intervention, and even the absence of intervention entirely, were included.

In the current review, negative bystander behavior was characterized as any response to cyberbullying which encourages bullying, including the absence of intervention as it is viewed as silent approval and reinforcement of the act of bullying, and "aggressive defending" through which a bystander defends the victim *via* acts of aggression against the bully. Other such acts include reinforcing the bully by assisting them, encouraging them through laughing along or sharing the content with others, and the like. This would indefinitely exclude articles which only address positive and constructive bystander behavior which express support toward the victim and disapproval of cyberaggression without the use of excessive aggression.

Additionally, articles which do not clearly identify the relationship between identified factors and negative bystander behavior and approach the topic through the lens positive bystander behavior will also be excluded to avoid misinterpretation of the results. The criteria are better presented in Table 1.

Literature search and screening

The literature search was split into two sections, whereby the first part of the search involved using search engines of literature databases to recall articles relevant to the keyword string input, and the second part involved a backwards and forwards search using relevant articles.

Through the preliminary literature search using the literature databases, 4,410 articles were identified and were screened based on their abstract and title. This preliminary screening resulted in 132 articles being identified and selected for further screening. On the other hand, as for the backwards and forwards search, a randomly selected article published in 2020 and 2013, respectively, were used to fill timeline gaps. The literature database "*Web of Science*" was used for these processes, which resulted in 25 most relevant articles being

TABLE 1 Screening criteria.

Criteria	Inclusion	Exclusion
Timeline	Between 2012 and 2022	Before 2012
Language	English	Languages other than English
Type of articles	Research articles	Articles other than research articles (e.g.,: review, conference proceedings, books, etc)
Content	Factors influencing negative bystander behavior and decision making in cyberbullying situations	Does not address factors influencing negative bystander behavior and decision making in cyberbullying situations (e.g.,: articles that discuss traditional bullying, positive bystander behavior, etc)

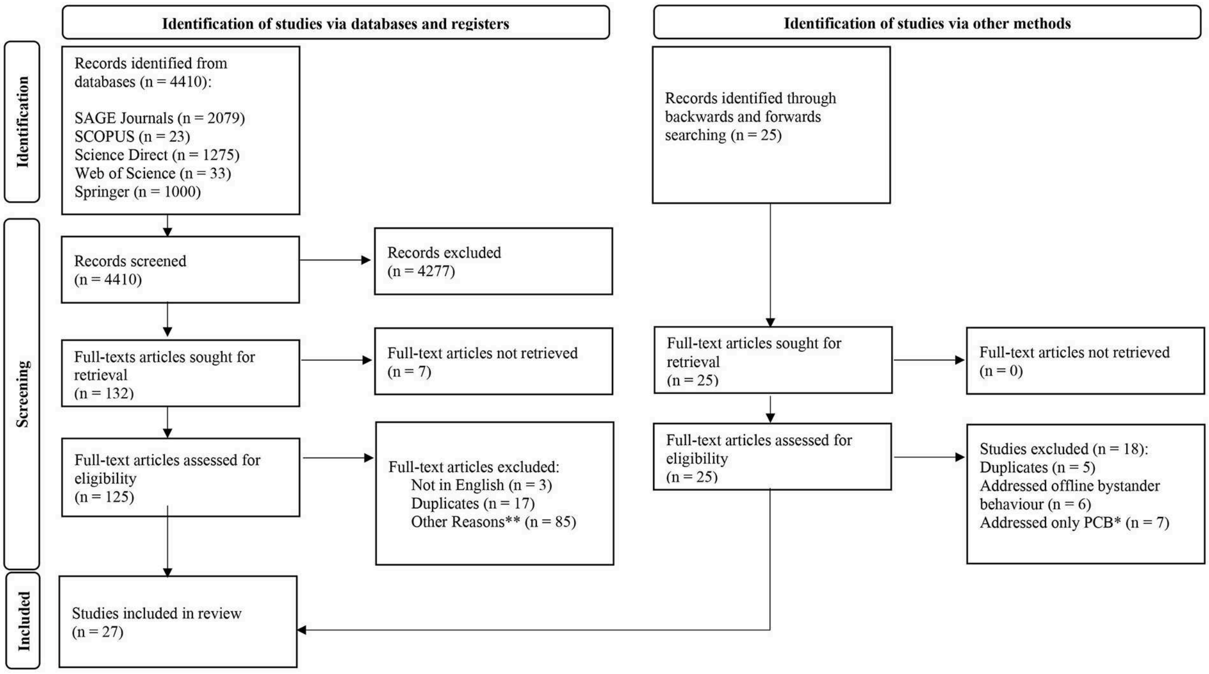

FIGURE 1
PRISMA flow-diagram. Source: Page et al. (29).

identified through the screening of their title and abstract alone. Next, upon the removal of articles that could not be accessed, were not written in English and were duplicates, authors were left with 116 articles to be screened. These articles were screened based on their full-texts to determine whether or not they met the inclusion criteria set. This resulted in 27 relevant articles being selected as the most suitable to be included in systematic review and fulfill the research objective of identifying the factors associated with negative bystander behavior. The process is presented in the PRISMA (Preferred Reporting Items for Systematic Reviews) flow-diagram (Figure 1).

Selected articles were then screened for author names, age range of participants, study design, types and prevalence rates of negative cyber-bystander behavior, and lastly the factors that contribute to negative cyber-bystander behavior. The data extracted are presented in Table 2 and discussed in the following section.

Some of the reasons articles were excluded include the fact that they did not discuss negative cyber-bystander behavior, and discussed positive cyber-bystander behavior [e.g.,: (30–33)], addressed bystander behavior in offline settings [e.g.,: (34, 35)], addressed cyberaggression rather than reinforcement of the act through negative cyber-bystander behavior [e.g.,: (36–38)], how people protect themselves [e.g.,: (39)], and the like instead.

Results

The analysis of included studies reveal that there are four different types of negative cyber-bystanders—passive bystanders, assistants, reinforcers and aggressive defenders. These bystanders, remain passive, join in on the aggression, show support for the aggressor, and aggress against the aggressor, respectively. "Showing support for the aggressor" within this review, was found to be limited to behaviors such as sharing the incident with others with the intent of making fun of the victim, laughing at the incident, telling the aggressor that they found the situation funny, and cheering on the bully. On the other hand, "aggressive defending" included behaviors such as threatening the aggressor, spreading rumors about the aggressor, or releasing their private information online, saying mean things about the aggressor and lastly, asking the aggressor to "back off".

Out of the twenty seven studies included in this review, only eleven studies reported prevalence rates of negative cyber-bystander behavior, and these rates fell between the ranges of 1.8–55.4%, depending on the type of behavior measured. The most common negative cyber-bystander behavior was passive bystander behavior, with prevalence rates ranging from 10.55 to 55.4%, followed by reinforcers, assistants, and aggressive defenders with rates as low as 1.8% and a maximum of 26.3% overall. While the

TABLE 2 Articles included in the study.

References	Age range/mean age (years)	Study design	Type/prevalence of negative bystander behavior	Factors influencing negative bystander behavior and decision making & their prevalence
Balakrishnan (48)	21.0	Cross sectional quantitative survey	61.5% defended the victims, 40.1% didn't do anything, 17% supported the bully	Safety, believed that it was not their problem
Barlinska et al. (42)	11–18	Experimental	Passive bystander behavior, reinforcer	Previous experience as cyber-aggressor, private nature of act
Bastiaensens et al. (28)	15.78	Cross sectional data analysis (data obtained from 4th wave of Longitudinal study)	5% joined the bully	Perceptions pertaining to peers' approval of cyber-aggression, Frequency of experience as a cyber-aggressor
Bastiaensens et al. (31)	13.29	Experimental quantitative survey	Reinforce bully by; sharing it with others to make fun of the victim, Telling the bully that you find it funny, Doing something similar	Behavior of good friends when faced with a bullying situation
Bauman et al. (50)	13.69	Exploratory analyses	10.55% did not intervene	51% Didn't know what to do, 38% Not my business, 38% I am too shy, 28% Didn't want to be a "snitch", 28% Afraid of being bullied, 16% The bully is popular, 16% It wasn't that serious, 12% don't care, 11% didn't like the person being bullied, 11% I thought the victim could take care of it themselves, 11% "Others didn't do anything so why should I?", 8% The bully is my friend.
Bussey et al.. (54)	11–15	Quantitative Survey	Aggressive defending: Saying mean things about the bully, Threatening the bully, Asking the bully to "back off"	Low defending self-efficacy, moral disengagement
Chan et al. (49)	Students: 13–17 years old Counselors: 29–57 years old	Hermeneutic phenomenological Study	Passive bystander behavior, reinforcing aggressors	Ignorance about cyberbullying and its effect, moral disengagement, fear, severity of incident, did not want to be involved
Cleemput et al. (43)	9–16	Cross sectional Quantitative survey (contained open ended questions)	35.2% Bystanders: Passive bystanders, Assistants	Age, empathy, past experience as a cyber-aggressor or witness, 31.8% Fear of retaliation, 30.6% lack of skill, 15.4% lack of self-efficacy, 13.0% displacement of responsibility, 49.0% believed that it was not their responsibility, difficulty assessing the situation, asynchronicity
DeSmet et al. (52)	13.61	Cross sectional quantitative survey (contained open ended questions)	55% did nothing, 41.3% deleted support for their victim, 14.6% laughed without letting anyone notice, 10.4% laughed while letting the bully notice (reinforcing the bully), 1.8% forwarded the content to someone else	Intentions to resort to negative bystander behavior, positive attitudes toward negative bystander behavior, higher expectations that negative bystander behavior would lead to personal gains, low problem-solving skill, lower empathetic skills, cognitive restructuring, lack of supportive factors that encourage positive bystander behavior
Erreygers et al. (41)	12.6	Cross sectional quantitative survey	53.6% did nothing, 4.6% joined the bully	Low empathy, high impulsivity, age

(Continued)

TABLE 2 (Continued)

References	Age range/mean age (years)	Study design	Type/prevalence of negative bystander behavior	Factors influencing negative bystander behavior and decision making & their prevalence
Gahagan et al. (55)	21	Quantitative survey (with qualitatively analyzed open ended questions)	Passive bystander behavior	Diffusion of responsibility, severity of bullying, relationship with victim
Koehler and Weber (61)	21.3	Experimental	Passive bystander behavior	Severity of the incident
Levy (65)	16.31	Cross sectional quantitative survey	45% Bystanders in total, 18.2% passive bystanders, 10.8% aggressor-supporters	Parental monitoring
Luo and Bussey (57)	12–15	Cross sectional quantitative survey	Aggressive defending: Threaten bully, Say mean things about the bully, Put the bully's information online, Make up rumors about the bully	Greater general and contextual moral disengagement
Machackova et al. (46)	15.1	Cross sectional quantitative survey	12% were passive bystanders	Relationship with the victim, gender, high self-esteem
Machackova and Pfetsch (53)	14.99	Cross sectional quantitative survey	Join the bully in bullying	High normative beliefs that aggression is an appropriate response to provocation
Moxey and Bussey (69)	13–16	Cross sectional quantitative survey	Aggressive defending	Past-experience as cyber-aggressor
Olenik-Shemesh et al. (51)	12.87	Cross sectional quantitative survey	55.4% passive bystander behavior	16.8% fear, 38.6% "Not my business"
Panumaporn et al. (44)	14.97	Cross sectional quantitative survey	26.3% Assistants, 28% passive bystander	Past-experience as cyber-aggressor, relationship with victims and/or other participants
Patterson et al. (63)	13–16	Vignette interview	Assistants, passive bystander behavior	Interpretation of situation, gender of protagonist, relationship with participants, severity of the incident
Patterson et al. (59)	13–16	Qualitative interview	Passive bystander	Absence of physical danger, lack of rules and absence of figures of authority online
Schultze-Krumbholz et al. (47)	13.44	Cross sectional quantitative survey	8.1% assistants, 9.5% aggressive defenders, 28.4% outsiders	High levels of reactive aggression, experience as cyber-aggressor and/or cyber-victim, low levels of socio emotional competencies, lack of empathy
Schultze-krumbholz et al. (40)	11–17	Cross sectional quantitative survey	Assistant	Less positive peer interactions in class
Song and Oh (64)	16.5	Cross sectional quantitative survey	60.7% outsiders, 5.4% reinforcers, 3.3% assistants	Positive relationship with the bullies
Tong (58)	8–16	Experimental vignette	Passive bystander behavior	Moral disengagement, low moral responsibility, past experience as bully-victims
Wang et al. (45)	18+	Cross sectional quantitative survey	Passive bystander behavior	Gender, age
You and Lee (60)	25–51	Experimental	Passive bystander behavior	Anonymity, number of bystanders

TABLE 3 Factors influencing negative cyber-bystander behavior identified in the current review.

Categorization	Factors
Personal factors	**Demographic background**
	• Age
	• Gender
	Beliefs, norms and outcome expectations
	• Perceived rewards
	• Perceived harm
	• Positive attitudes toward negative cyber-bystander behavior
	Skills and self-efficacy
	• Lack of problem-solving skills
	• Low socio-emotional skills
	• Low social self-efficacy
	• Perceived lack of defending skills
	Low empathy
	Aggressive tendencies
	Moral disengagement and responsibility
Situation factors	**Characteristics of cyberspace and computer mediated communication**
	• Lack of physical aggression
	• Lack of clear rules
	• Lack of guidance online from authority figures
	• Delayed exposure to the event
	Privacy of the incident
	Anonymity
	Interpretation of the incident
	• Perception that the event is not severe enough to warrant intervention
	• Perception that the incident is banter
	• Feelings of enjoyment when witnessing the event
	• Belief that the victim can handle the situation
	• Uncertain of the nature of the situation
	Other participants
	• Behavior of other cyber-bystanders
	• Presence of other cyber-bystanders
	• Gender of protagonist
Social influence	Relationship with other participants
	Popularity of aggressor
	Perceived peer response
	Parental monitoring
	School environment
	• Lower levels of positive peer relationship
	• Higher number of aggressors in class

prevalence of the latter types of negative cyber-bystander behaviors are much less common, they have a more direct effect on the victim, and the severity and/or direction of an incident.

In terms of the factors that were associated with these behaviors on the other hand, the analysis of the results indicates that the most studied variables were what the current review categorizes as "personal factors", and the least commonly addressed variables were associated with social influences. Moreover, there are a noteworthy number of studies which both, studied and loosely addressed "mediating" variables to explain the motivation behind negative cyber-bystander behaviors. Additionally, many studies had discussed certain parts of their findings (i.e.,: the relationship between the variables studied and cyber-bystander behavior) in relation to constructive cyber-bystander behavior without clarifying how or if said variables influence or are associated with negative cyber-bystander behaviors. Hence, only certain variables from these studies can be reported within the current review, and are reported alongside other details of the study in Table 2. Following that, the factors associated with negative cyber-bystander behavior which were identified through the review process were then grouped into three categories, namely (a) personal factors, (b) situational factors, and (c) social influence, and are presented in Table 3, and discussed in the sections below.

Personal factors

These factors address qualities unique to an individual, such as their demographic backgrounds, their past experiences, levels and usage of moral disengagement strategies, empathy levels, skills and beliefs pertaining the efficacy of their capacity.

Demographic background

While various demographic factors were addressed, age and gender were the most commonly studied across the articles included in this review and were the only demographic factors identified as being significantly associated with negative cyber-bystander behavior, with some exceptions which provided contradicting results by Schultze-Krumbholz et al. (40), Erreygers et al. (41), and Barlinska et al. (42).

With regards to age, it was noticed that older individuals expressed more reluctance to intervene (41), and were more likely to remain passive as a bystander (43) or join in on the aggression (43, 44). The lack of constructive intervention and higher negative cyber-bystander behavior among older individuals in the sample populations were rationalized using low empathy scores (45), the increase in anti-social tendencies in older adolescents (44) and social influence such as the fear of judgment by peers (41).

Gender differences reported by the studies included in the review, on the other hand, seemed to consistently indicate that male individuals were more prone to negative cyber-bystander behavior, in comparison to their counterparts. Not only was it identified that boys had a higher likelihood of being passive (45, 46) and possessing higher behavioral intention to reinforce the aggressor (31), being male could also significantly predict an individual's involvement as an assistant (47). However, variables such as moral disengagement strategies which distort the consequences of their behaviors, as well as perceived severity were found to moderate the relationship between gender and pro-aggressor behaviors in the study by Schultze-Krumbholz et al. (47), suggesting that the relationship between gender and negative cyber-bystander behavior might not be very straightforward and will require further analysis.

Past experience as an aggressor or victim

Unsurprisingly, studies found that individuals with past experience as an aggressor were more likely to be associated with negative cyber-bystander behavior (28, 42–44). This was true for both traditional aggressors who engaged in face-to-face aggression, as well as cyber-aggressors who were bullies in cyberspace (43). Panumaporn et al. (44) elaborated on these results, stating that individuals who were bullies tend to hold positive beliefs pertaining to the use of aggression and that this attitude is likely to be reflected in their behavior as cyber-bystanders as well. Moreover, individuals who were aggressors did not feel pressured into joining in on the aggression as cyber-bystanders (28). On the other hand, it was identified that aggressive defenders were also more likely to have had experiences of being cyber-victims in the past, in comparison to their peers who engaged in more prosocial behaviors (47).

Beliefs, norms, and outcome expectations

Seven different studies identified differing normative believes, outcome expectations and attitudes pertaining to cyber-aggression or bystander behavior. Put simply, the findings of these studies indicate that individuals tend to engage in behaviors that they perceive would result in either a reward or the avoidance of harm. For example, individuals stated that they remained passive for safety reasons (48) or the fear of being victimized in the process of defending a victim (43, 49–51). On the other hand, DeSmet et al. (52) found that individuals were also prone to remaining passive or reinforcing the aggressor if they expected to be rewarded with a rise in social status, the possibility to gain new friends, for self-protection or if they held positive beliefs about their choice of response as a bystander. Additionally, it was also noticed that individuals who believed that aggression was a valid response to provocation, as well as those who had lower levels of defending normative beliefs were moe likely to resort to pro-bullying behavior that reinforces aggression (53).

Skills and self-efficacy

Whether or not individuals possessed the skill or the belief that they were capable of effectively handling an incident of cyber-aggression as a bystander, was found to be associated with negative bystander behavior. In essence, individuals who lacked self-efficacy or the skills to intervene, had a higher tendency to become negative bystanders (43). While participants in the study by Bauman et al. (50) simply stated that the "did not know what to do" in response to why they remained passive, more specific factors such as the lack of defending self-efficacy (54), social self-efficacy and knowledge (55), as well as low socio-emotional skills (47), self-reliance, and problem-solving strategies) were linked to the increased tendency to resort to negative cyber-bystander behavior. Van Cleemput et al. (43) suggested that the lack of control individuals have over an incident of cyber-aggression, such as the inability to prevent something from going viral given the public nature of cyber-space as well as the speed through which information spreads digitally, could contribute to the perceived lack of skills (i.e.,: low self-efficacy) among individuals. It is important to note, however, that the adolescents in the study by Bussey et al. (54) neither remained passive nor reinforced the aggressor, but instead resorted to aggressive defending styles by redirecting the aggression toward the aggressor when they lacked the self-efficacy to defend individuals in more constructive ways.

Empathy

Cross-sectional studies show that lower levels of empathy was able to predict individuals' negative bystander behavior (43, 47). Additionally, an empathic reaction was found to be the only differentiating factor between bystanders who respond in supportive ways and those who chose to remain passive (46). Lastly, a noteworthy finding by Machackova et al. (46) indicates that it's likely that empathic reactions could be reliant on contextual factors that might play a more crucial role in determining the final response.

Aggressive tendencies

Without surprise, studies found that more aggressive individuals had a higher tendency to assist aggressors (47). Schultze-Krumbholz et al. (47) highlighted reactive aggression in particular and suggested that the behavior is likely influenced by impulsivity and identified this group of individuals as being at a higher risk of becoming aggressors, in comparison to their peers.

Moral disengagement and responsibility

Moral disengagement was found to be one of the more prominent theme and variable in this review, with seven different studies highlighting its link to negative bystander behavior. It is defined as a mechanism that allows an individual to reconstruct their beliefs about negative and harmful behaviors by either minimizing or distorting the consequences of said behaviors, or shifting the blame and/or responsibility away from themselves or onto others, allowing them to justify engaging in such behaviors (56). The results presented by the studies indicate that individuals who were more morally disengaged were also more prone to engaging in aggressive defending (54, 57), as well as positive bystanding (49, 58). This is likely because moral disengagement processes provide individuals with the tools to justify their behavior (49), even in the event that they behave in ways that contradict their own values (58).

Van Cleemput et al. (43) who studied the influence of various aspects moral disengagement mechanisms identified that diffusion of responsibility, attribution of blame, and distortion of consequences as well as displacement of responsibility as being factors that are positively linked to negative cyber-bystander behavior. Similar patterns can be found in other studies as well, where individuals who had low levels of moral responsibility (58) or believed that it was "not their problem" (48, 50, 51, 55) were more likely to be negative bystanders. DeSmet et al. (52) on the other hand, found contradicting evidence pertaining the mechanism of attribution of blame, whereby lower victim blaming tendencies were associated with passive bystander behavior, suggesting that it is possible that individuals were behaving in ways that go against their own beliefs.

Situational factors

Characteristics of cyberspace and computer mediated communication

Three different characteristics of computer mediated communication (CMC) were identified through this study. The first being the absence of physical aggression which diminishes the severity of the event in the eyes of cyber-bystanders (59). Secondly, student's suggested that the lack of rules and authority figures present in online spaces, to provide guidance, led them to remain passive when they witnessed incidents of cyber-aggression (59). Lastly, it was noticed that the increase in tendency to be a passive bystander was contributed by the bystanders' delayed exposure to the incident of cyber-aggression (43).

Privacy

Participants in a study by Barlinska et al. (42) were found to be more likely to remain passive as a bystander when the incident they had witnessed was private in the nature. The researchers theorized that it was the result of the lack of social pressure to conform to social norms, which is present in situations where there is a large audience.

Anonymity

In the study by You and Lee (60), it was identified that the intention to intervene was more influenced by their own anonymity or lack thereof, rather than the number of cyber-bystanders present.

Interpretation of the incident

In most of the reported findings addressed in the studies included in the current review, it was noticed that individuals were more likely to remain passive if they perceived a situation as being not severe enough to require intervention (49, 50, 55, 59, 61). This falls in line with the Bystander Theory by Latane and Darley (62), which states that individuals need to perceive the situation as being an emergency that requires their intervention in order to engage in proactive and constructive bystander behavior. Additionally, it was also identified that individuals remained passive if they assumed that the victim had the capacity to handle the situation themselves, or if they found enjoyment in witnessing the incident (50)—it seems reasonable to assume that that this would have made a situation seem less like an emergency that requires their intervention.

In addition to the perceptions about the severity of the incident, two studies found that bystanders also remained passive when they experienced difficulty in interpreting the nature of the incident they are witnessing (43, 63) and/or were uncertain about who was responsible for the incident (43). On the other hand, they were more likely to engage in behaviors that reinforce the aggression and aggressor if they believed that the event they were witnessing was a joke between parties involved (63).

Other participants

Cyber-bystanders' behavior was found to be influenced by not just the behavior of other bystanders (31, 49, 50) but also the number of bystanders present (60, 64), as well as the gender of the protagonist (63) involved in an incident of cyber-aggression. Through this review, it was noticed that bystanders were likely to reinforce aggressor (31) or remain passive (50), if other bystanders, especially close friends were to engage in such behaviors (31). Additionally, the "bystander effect" which states that individuals are less likely to intervene in the presence of a large audience, was present in reports by Song and Oh (64) as well as You and Lee (60). However, it was reported that passive bystander behavior was possible even in the absence of other bystanders, in the event that these bystanders had a positive relationship with the aggressor(s), likely to preserve their relationship with the aggressor (64), suggesting that there are other important contextual factors that need to be taken into account when addressing the number of bystanders and its relationship with the behavior of bystanders.

Lastly, a lone study by Patterson et al. (63), in which adolescents were allowed to freely state their reasons for passive behavior, it was identified that individuals did not want to intervene in situations where the protagonists were female as they believed that the situation was less controllable than when the protagonists were male.

Social influence

Relationship with other participants

As addressed in an above-mentioned section, bystanders' behavior was also found to be influenced by their relationship with the participants involved in an incident they had witnessed. For example, if they were friends with aggressor, they were more likely to reinforce or ignore the incident and disregard the plight of the victim (50, 64) in order to maintain their relationship with the aggressor (64). However, Song and Oh (64) clarified that this behavior was context dependent and relied on the absence of other bystanders, as the presence of other bystanders would lead to defending behaviors.

Additionally, bystanders were also found to remain passive when they were not closely acquainted with or had a bad relationship with the victim (46, 50, 55), or in the event that they did not have a close relationship with any participant involved in the incident of cyber-aggression they witnessed (44, 63). It could be because individuals perceived levels of responsibility based on the closeness of their relationship with the victim (55)—the closer they were, the more responsibility they had to intervene and defend the victim, and vice versa (44). It could possibly be explained by how people tend to view individuals from their in-group and their out-group as most people tend to prioritize their in-group (i.e.,: individuals they identify with, and are close to) in comparison to those who are more distant to them (44). Machackova et al. (46) on the other hand, theorized that an individual's relationship with the victim could influence their perception of the severity of the event they are witnessing, meaning the closer they were to the victim, the more severe they would perceive an incident to be. According to the "bystander effect" theory and the bystander intervention model, a lower perception of severity would lead to passivity in the face of aggression as a bystander.

Popularity of aggressor

The popularity of the aggressor was stated as a reason why 16% of the bystanders in the study by Bauman et al. (50) had refrained from intervening and had chosen to remain as passive bystanders. It could be that going against a popular individual who holds a higher social status costs a lot more than individuals are willing to deal with.

Perceived peer response

In the event that individuals held the perception that their peer would support or expect them to join in on the bullying, they were more likely to join in on the bullying and reinforce the aggression against the victim, to maintain their relationships and social status (28, 31).

Parental monitoring

Only Levy (65) addressed the influence of parental monitoring. It was noticed that higher aggressor-supporter scores were positively associated with the behavior of reinforcing and supporting aggressors. However, it was not expressed as a causal relationship and authors suggest that restrictions could be the consequence of aggressor-supporter behaviors and questioned the efficacy of such measures if it were the case.

School environment

Schultze-Krumbholz et al. (40) found that lower levels of positive peer interactions in class was associated with assistant behavior cyber-aggression situations. Additionally, they also stated that classrooms that contained a higher number of offline-aggressors tend to promote more negative cyber-bystander behavior—likely due to social norms and pressure.

Discussion

The acknowledgment of the influence of cyber-bystanders in influencing incidents of cyber-aggression has allowed for a more complete understanding of the mechanism of cyber-aggression, which in turn allows for the identification of crucial risk factors that contribute to the reinforcement and/or prevalence of the phenomenon. While these individuals known as negative cyber-bystanders, in contrast to the more constructive cyber-bystanders, have been studied for a while now, the data obtained are scattered and lacking. Hence the current review aims to compile, present and discuss existing findings from journal articles published in the past decade, to provide a more coherent look at the data, and highlight potential findings of interest that may aid in the identification of future research questions. The discussion will be broken into several sections which will discuss the factors associated with negative cyber-bystander behavior, as well as directions for future studies and limitations of the current review.

Factors associated with negative cyber-bystander behavior

Based on the review of the results and discussions produced by the studies included, it appears evident that negative cyber-bystander behavior is the result of the interaction of multiple factors, and that mediating and moderating factors should be of focus and rigorously studied to better understand the phenomenon. Despite the complexity of the associations between the variables of interest, several notable themes were identified. Firstly, the review indicates that the Bystander Intervention Model introduced by Latane and Darley in 1970 (61) was a relatively simple yet useful model that identified noteworthy precursors to negative cyber-bystander behavior.

Latane and Darley's (62) Bystander Intervention Model posits that (a) the perception of the severity of an incident and need for intervention, (b) accepting responsibility to intervene and (c) having the capacity to intervene were important precursors to bystander behavior (61). The findings identified through the review echoed this, as those who (a) minimized the severity of the event (49, 50, 55, 59, 61), (b) did not think that it was their responsibility to intervene (43, 48, 50, 51, 55), and those who had neither the necessary skills and knowledge (43, 50) nor the self-efficacy to intervene (54), had consequently resorted to negative cyber-bystander behavior.

The need for intervention appears to be assessed in two ways; based on (a) the severity of the incident and (b) the capacity of the individuals involved to manage the situation without additional intervention. Evidently, those who believed that victims (50) or other bystanders (49) would accept the responsibility and have the capacity to effectively resolve or handle the situation were more likely to detach themselves from the situation and remain as passive bystanders. Those who had the tendency to minimize the severity of a situation, however, did not consistently adopt the role of a passive bystander as a result. For instance, individuals consistently ignored the incident when they perceived the absence of physical aggression to mean that the situation was not severe enough (59), or because they perceived the inaction of other bystanders as a sign that there was no need for intervention (49). On the other hand, while some individuals remained passive when they perceived the incident as being mere banter among peers (63), others had chosen to reinforce it (49, 63). This implies that there may be two stages in the process leading to a behavioral response, whereby the initial step involves factors that first influence the perception of the severity of the event, followed by the second step which includes an additional variable that subsequently influences the resulting type of negative cyber-bystander behavior.

An individual's perception regarding their responsibility to intervene, on the other hand, was in many instances associated with the nature of their relationship with participants involved in the incident, as individuals only felt more responsible to intervene when they were close to the victims (44, 55), hence were less likely to intervene when they had neither a close nor positive relationship with the victim (43, 46, 50, 55) or any other participant in general (44, 63). Moreover, when faced with ambiguous situations that make it difficult for individuals to even identify whether intervention is necessary, a close relationship with other participants would allow them to directly request for further context or clarification, and subsequently determine whether they must or want to intervene (63). Whereas, those with a weaker relationship with other participants would be deprived of this opportunity. Given the lack of contextual information present online, and the fact that the ambiguity of a situation leads individuals to remain passive, this presents as a vital finding (43, 63).

Regarding the lack of skills that were associated with negative bystander behavior, as mentioned in the result section, both the lack of problem-solving (52) as well as socio-emotional skills (47) resulted in negative cyber-bystander behavior. Similarly, factors like the lack of self-reliance (52), defending self-efficacy (50, 54), general self-efficacy (43), social self-efficacy (55) and components of empathy (43, 47), which are associated with these skills, were also associated with an increased likelihood that individuals would resort to negative cyber-bystander behavior. Building these skills and improving one's self-efficacy, which could promote later positive cyber-bystander behavior, requires both, the opportunity to learn and to practice those skills. One of the reasons that hinder these possibilities is the reliance on others, like authority figures, when faced with incidents of cyber-aggression, rather than relying on themselves, as it would likely decrease the opportunities to build these necessary intervention skills (59). Therefore, although teaching individuals to reach out to authorities or others who may be able to help or guide them is necessary, it is also important to create opportunities for them to develop these crucial skills.

Moreover, one's environment needs to promote these behaviors as being desirable behavior in order to further encourage it as the review indicates that individuals tend to engage in these behaviors if they believe that their peers expect (28) or will reward such behaviors (52), or that it would keep them safe (43, 49–51). This includes efforts to discourage both face to face and online cyber-aggression as those who were in classrooms with a higher number of aggressors were more likely to reinforce aggression (40). In addition to that, efforts to improve poor peer relationships and peer support also seem vital as factors such as self-efficacy were found to be associated with these variables (51), and it might also increase one's sense of safety when they have adequate social support. Based on the above-mentioned section, it also seems reasonable to believe that good peer relationships have the potential to promote a higher sense of responsibility (44) to engage in incidents of aggression as constructive cyber-bystanders.

It shouldn't go unnoticed that some individuals who lack defending self-efficacy may still assist the victim, albeit resorting to aggressive behaviors directed at the aggressor

(54). This indicates that some individuals may have the correct intention, the ability to understand that intervention is required, and subsequently choose to intervene, but choose retaliatory acts similar to that of cyber-aggressors rather than more constructive ways of intervening. Schultze-Krumbholz et al. (47) identified that factors such as past experience as either a cyber-victims or cyber-aggressors, lower socio-emotional skills, as well as higher reactive-aggression, and possibly also impulsivity as being associated with these individuals. Bussey et al. (54) and Luo and Bussey (57) on the other hand, caution that these individuals are more closely linked to aggressors rather than defenders, making it necessary to clearly differentiate the various types of negative cyber-bystander behavior rather than grouping them together.

Another important theme that was identified through the review was the fact that there seemed to be notable distinctions between factors associated with aggressive and passive types of negative cyber-bystander behavior, despite there being some overlapping variables. For instance, aggression, whether it's their own past experience as aggressors (28, 42–44), increased exposure to aggressors in their environment (40), or their belief that aggression can be a valid response (53), was naturally more likely to be associated with aggressive forms of cyber-bystander behavior. Moreover, these behaviors were also associated with the belief that it would result in favorable responses such as an improvement in social status or opportunity for new friendships (52). On the other hand, passive bystanders were associated with factors which were related to avoidance of undesirable consequences like a threat to their safety (48), potential victimization (43, 49–51), loss of friendships (43) and etc. As highlighted above, it also has to do with not accepting responsibility to intervene, as well. However, this should be interpreted with caution given that studies had rarely addressed or compared the different types of negative cyber-bystander behavior.

In addition to above-mentioned themes, moral disengagement strategies, whether or not explicitly studied, were observed to be present in many of the situations that were discussed in the findings of the study. Simply put, moral disengagement is a mechanism of thought through which individuals rationalize and justify their harmful or generally negative behaviors (56), which in the case of the study would subsequently lead to or is simply positively associated with negative cyber-bystander behavior (49, 54, 57, 58). It involves the use of strategies such as the attribution of blame, the displacement or diffusion of responsibility, cognitive restructuring, distorting consequences of an action and etc. (56), most of which can be identified within the current review even in studies outside of those that had provided empirical evidence pertaining to their relationship with negative cyber-bystander behavior.

Some of the examples include the diffusion of responsibility experienced by individuals in a large crowd (60), placing blame and the responsibility to handle the situation on the victim (43), detaching themselves from their aggressive friends and the consequences of their behaviors (64), trivializing their reinforcement of aggression and reframing it as mere banter (49) or just the minimization of the severity of the incident in general (43), among other things. Moreover, aside from reinforcer and passive bystanders, both empirical evidence and simple deduction suggest that aggressive defending, was associated with moral disengagement strategies (54, 57), as it requires individuals to justify why their use of aggression is morally correct while the aggressor's use of aggression was not. These findings suggest that individuals resort to moral disengagement strategies in order to simultaneously maintain their own moral identities while also engaging in negative cyber-bystander behavior without feelings such as guilt. Additionally, moral disengagement was found to moderate the relationship between gender and pro-aggressive bystander behavior, further implying that it might be the factor that distinguishes between individuals that resort to such behaviors and those who don't (47).

Similarly, the bystander effect, as introduced by Latane and Darley (62), which suggests that individuals tend to resort to being passive in the presence of other bystanders (60), was proven by Chan et al. (49) and You and Lee (60) but contradicted by Song and Oh (64). This indicates that even the presence or absence of other bystanders did not consistently predict the way in which individuals will react to an incident of cyber-aggression, as some bystanders were more constructive in private situations where no or very few bystanders were present (64) while others were more likely to remain passive in a similar situation (42), and some others were passive in the presence, not absence of other bystanders (60). Therefore, it seems likely that a larger crowd, in some situations would increase the social pressure an individual experiences to behave in socially acceptable ways (42), while it encourages the diffusion of responsibility in others (60), and that other contextual factors should be taken into account. For instance, individuals with a close relationship with the aggressor were more likely to remain passive in the absence of other cyber-bystanders but were more likely to behave constructively in the presence of other bystanders (64), possibly because they found safety in numbers.

Lastly, although this phenomenon is one that occurs in cyber-space, there were very few papers which identified or acknowledged the influence of the characteristics of cyber-space and computer mediated communication on leading individuals to resort to negative cyber-bystander behavior. From what was reported, however, it can be gathered that the lack of context cues can complicate matters relating to the interpretation of the event and subsequently one's response as a cyber-bystander. Additionally, it seems as though individuals have the tendency to perceive cyber-aggression as being less severe than face-to-face aggression, solely due to the absence of physical aggression in the former, suggesting that there is a lack of awareness regarding the effects of cyber-aggression due to these differences. Moreover, asynchronicity which can cause a delay between when the incident had occurred and when the cyber-bystander witnesses it may leave individuals believing that there is no other response other than ignoring the incident as there is neither a need nor value in intervening in a situation that has already passed and might have been resolved (43). Besides that, in You and Lee (60), it was discussed that individuals are less likely to choose more constructive cyber-bystanders behavior, likely due to the fact that they fear negative judgments a lot less in such situations. Other than that, there seems to be very little empirical evidence and the discussion it fueled, regarding the ways in which the characteristics of cyberspace and the pattern of communication in such platforms influence negative cyber-bystander behavior.

Future studies

Based on the review of demographic factors associated with the participants included in the studies reviewed, it is evident that the focus was largely on the pre-teen and adolescent population, aged between 12 and 16, with only six out of 27 studies addressing the adult population, and even fewer studies which included children ages 8–10. Hence, future studies should consider investigating negative cyber-bystander behavior among the adult population as well as well as younger children considering that the age at which individuals are exposed to the internet and technological devices seems to be decreasing. Moreover, various factors such as empathy, technological savviness, the need for external guidance and others might manifest differently among different age groups.

Secondly, most of the studies were carried out in the United States of America (USA) or European countries with very few addressing countries from other regions with differing cultures and norms. Given that these differences can subsequently influence thought and behavioral outcomes, it seems necessary to widen the scope of the study in terms of geographical locations, to account for cross-cultural differences. Additionally, most studies were cross-sectional surveys, more longitudinal studies as well experimental designs should be explored. In addition to that, there was a great benefit in collecting qualitative data from participants, hence, this practice should be encouraged even in the smallest ways in future studies.

Future studies could also go beyond the biological binary when discussion gender differences and account for more personal differences. The differences can include factors such as normative beliefs associated with gender, particularly with regards to aggression, empathy, outcome expectations, feelings of guilt and shame associated with negative cyber-bystander behavior, and the like. Moreover, difference in personality traits may also be worth exploring to identify variables that directly or indirectly influence an individual's choice of negative cyber-bystander behavior on a more personal level. In addition to that, factors such as moral disengagement, on the other hand, could potentially prove to be a vital moderating factor in future studies.

Future studies could also benefit from a more uniform way of measuring different types of cyber-bystander behavior to ensure some consistency across different studies. Most importantly, as identified above, more studies should address the ways in which the characteristics of cyberspace as well as computer mediated communication would influence an individual's decision to resort to negative cyber-bystander behavior. Various existing models and theories such as the online disinhibition theory by Suler (66) and the Barlett and Gentile Cyberbullying Model would be of use in doing so as they do indeed support findings presented by studies such as You and Lee (60) and Van Cleemput et al. (43).

Limitations

There are a number of limitations and shortcomings in several aspects of the study ranging from the literature search, data analysis to the determination of the quality of the study. Firstly, although the choice of keywords used, as well as the strict inclusion criteria were selected and employed in order to ensure that only relevant data would be retrieved, it could have inadvertently excluded other significant literature which could have further enriched the current review. For instance, while the peer-reviewed articles published in the past ten (10) years might be able to better capture dynamics of the phenomenon in the current cyber landscape, it is likely that literature published prior to the past decade might contain important information that the current review may have benefitted from. The omission of gray literature would have impacted the review in similar ways. Moreover, limiting the literature search to five databases might have lead to the omission of important literature that could be found on other online databases or registers. Lastly, it should be taken into account the screening process could have been impacted by human errors. However, the review has managed to fulfill the aim of compiling, presenting and discussing important findings that provide a simple overview of negative cyber-bystander behavior.

Moreover, the reproducibility or the replicability of the search can be affected by things out of the control of the authors, such as the changes made in the literature databases in terms of search retrieval systems, the addition or elimination of journals or articles and etc. (67). Additionally, the quality of the review is difficult to assess given that the extraction and analysis of data could be influenced by bias as they rely on the reviewers' and authors' interpretations and ideas, and the fact that the review consists of studies of varying designs (68).

Despite the flaws, the review, like any other has managed to compile, and present a comprehensive set of literature and discussion highlighting factors associated with negative bystander behavior, in addition to the possible interactions between them, as well as possible gaps to address in the future. Moreover, the review can be used as a point of reference through which further questions can be identified, in order to extend the scope of research.

Conclusions

Through the synthesis of literature included in this review, it is evident that is not only crucial to create an environment that facilitates and encourages positive bystander behavior, but also an environment that discourages and disincentivizes negative bystander behavior. This is especially true in the case of aggressive bystander behavior, as it would aid in not just preventing the reinforcement and/or exacerbation of an act of aggression by primary aggressors but could possibly prevent bystanders' potential future participation in acts of cyber-aggression. Moreover, the review indicates the necessity to take into consideration and further study in detail the interaction between multiple variables, as well as contextual factors, as a catalyst for negative bystander behavior as many of the studies have either theorized or proven that these are relevant in uncovering a clearer picture regarding this phenomenon. Lastly, the influence of technology on human behavior and interaction, in addition to the role of personal characteristics rather than a categorical approach to demographic differences may also prove to be useful directions for future studies to take.

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/s.

Author contributions

The study and its design were conceptualized by SJ and MK. The literature search was carried out in two steps, whereby the preliminary screening was conducted by SJ and the subsequent screening to select studies to be included was a joint effort between SJ, MK, SM, JK, and AA. Data organization and analysis, in addition to the writing of the first draft was carried out by SJ under the direction and supervision of MK. Lastly, the collective effort and agreement of all authors were involved in the process of proofreading and editing of subsequent drafts, as well as the approval of the final submitted manuscript.

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Conflict of interest

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

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.965017/full#supplementary-material

References

1. Alonzo R, Hussain J, Stranges S, Anderson KK. Interplay between social media use, sleep quality, and mental health in youth: A systematic review. *Sleep Med Rev.* (2021) 56:101414. doi: 10.1016/j.smrv.2020.101414

2. Güzel N, Kahveci I, Solak N, Cömert M, Turan FN. Internet addiction and its impact on physical health. *Turkish Med Student J.* (2018) 5:32–6. doi: 10.4274/tmsj.2018.05.03.0002

3. Rathakrishnan B, Singh SSB, Kamaluddin MR, Yahaya A, Nasir MAM, Ibrahim F, et al. Smartphone addiction and sleep quality on academic performance of university students: An exploratory research. *Int J Environ Res Public Health.* (2021) 18:8291. doi: 10.3390/ijerph18168291

4. Tateno M, Teo AR, Ukai W, Kanazawa J, Katsuki R, Kubo H, et al. Internet addiction, smartphone addiction, and hikikomori trait in japanese young

adult: Social isolation and social network. *Front Psychiatry.* (2019) 10:1–11. doi: 10.3389/fpsyt.2019.00455

5. Lin L, Liu J, Cao X, Wen S, Xu J, Xue Z, et al. Internet addiction mediates the association between cyber victimization and psychological and physical symptoms:moderation by physical exercise. *BMC Psychiatry.* (2020) 20:1–8. doi: 10.1186/s12888-020-02548-6

6. Craig W, Boniel-Nissim M, King N, Walsh SD, Boer M, Donnelly PD, et al. Social media use and cyber-bullying: a cross-national analysis of young people in 42 countries. *J Adolesc Heal.* (2020) 66:S100–8. doi: 10.1016/j.jadohealth.2020.03.006

7. Jenaro C, Flores N, Frías CP. Systematic review of empirical studies on cyberbullying in adults: what we know and what we should investigate. *Aggress Violent Behav.* (2017) 38:113–22. doi: 10.1016/j.avb.2017.12.003

8. Guo SA. Meta-analysis of the predictors of cyberbullying perpetration and victimization. *Psychol Sch.* (2016) 53:432–53. doi: 10.1002/pits.21914

9. Hua TK, Hwa NSH, Chong ST. Cyberbullying victimization and cyberbullying perpetration with self-esteem as the moderator. *Int J Recent Technol Eng.* (2019) 8:88–92. doi: 10.35940/ijrte.B1014.0982S1019

10. Zhu C, Huang S, Evans R, Zhang W. Cyberbullying among adolescents and children: A comprehensive review of the global situation, risk factors, and preventive measures. *Front Public Health.* (2021) 9:1–12. doi: 10.3389/fpubh.2021.634909

11. Sabramani V, Idris IB, Ismail H, Nadarajaw T, Zakaria E, Kamaluddin MR. Bullying and its associated individual, peer, family and school factors: Evidence from Malaysian National Secondary School Students. *Int J Environ Res Public Health.* (2021) 18:7208. doi: 10.3390/ijerph18137208

12. Dennehy R, Meaney S, Cronin M, Arensman E. The psychosocial impacts of cybervictimisation and barriers to seeking social support: Young people's perspectives. *Child Youth Serv Rev.* (2021) 111:104872. doi: 10.1016/j.childyouth.2020.104872

13. Balakrishnan V, Norman AA. Psychological motives of cyberbullying among Malaysian young adults. *Asia Pacific J Soc Work Dev.* (2020) 30:181–94. doi: 10.1080/02185385.2020.1772101

14. Del Rey R, Casas JA, Ortega-Ruiz R, Schultze-Krumbholz A, Scheithauer H, Smith P, et al. Structural validation and cross-cultural robustness of the European Cyberbullying Intervention Project Questionnaire. *Comput Human Behav.* (2015) 50:141–7. doi: 10.1016/j.chb.2015.03.065

15. Ahmad Ghazali AH, Abu Samah A, Omar SZ, Abdullah H, Ahmad A, Mohamed Shaffril HA, et al. Development and validation of an instrument measuring cyberbullying among Malaysian youths. *J Cogn Sci Hum Dev.* (2019) 5:78–91. doi: 10.33736/jcshd.1921.2019

16. Aizenkot D, Kashy-Rosenbaum G. The effectiveness of safe surfing, an anti-cyberbullying intervention program in reducing online and offline bullying and improving perceived popularity and self-esteem. *Cyberpsychology.* (2020) 14:1–23. doi: 10.5817/CP2020-3-6

17. Gaffney H, Farrington DP, Espelage DL, Ttofi MM. Are cyberbullying intervention and prevention programs effective? A systematic and meta-analytical review. *Aggress Violent Behav.* (2019) 45:134–53. doi: 10.1016/j.avb.2018.07.002

18. Fortunatus M, Anthony P, Charters S. Combining textual features to detect cyberbullying in social media posts. *Proc Comput Sci.* (2020) 176:612–21. doi: 10.1016/j.procs.2020.08.063

19. Ali WNHW, Mohd M, Fauzi F. Identification of profane words in cyberbullying incidents within social networks. *J Infm Sci Theor Pract.* (2021) 9:24–34. doi: 10.1633/JISTaP.2021.9.1.2

20. Hua TK, So'od SMM, Hamid BA. Communicating insults in cyberbullying. *Search.* (2019) 11:91—109. Available online at: https://fslmjournals.taylors.edu.my/communicating-insults-in-cyberbullying/

21. Grigg DW. Cyber-aggression: definition and concept of cyberbullying. *Aust J Guid Couns.* (2010) 20:143–56. doi: 10.1375/ajgc.20.2.143

22. Corcoran L, Guckin C, Prentice G. Cyberbullying or cyber aggression?: a review of existing definitions of cyber-based peer-to-peer aggression. *Societies.* (2015) 5:245–55. doi: 10.3390/soc5020245

23. Hyland JM, Hyland PK, Corcoran L. Cyber aggression and cyberbullying: Widening the net. *Adv Sci Technol Secur Appl.* (2018) 5:245–55. doi: 10.1007/978-3-319-97181-0_3

24. Shultz E, Heilman R, Hart KJ. Cyber-bullying: An exploration of bystander behavior and motivation. *Cyberpsychology.* (2014) 8. doi: 10.5817/CP2014-4-3

25. DeSmet A, De Bourdeaudhuij I, Walrave M, Vandebosch H. Associations between bystander reactions to cyberbullying and victims' emotional experiences and mental health. Cyberpsychol. *Behav Soc Netw.* (2019) 22:648–56. doi: 10.1089/cyber.2019.0031

26. Wright MF, Wachs S, Harper BD. The moderation of empathy in the longitudinal association between witnessing cyberbullying, depression, and anxiety. *Cyberpsychology.* (2018) 12. doi: 10.5817/CP2018-4-6

27. Pabian S, Vandebosch H, Poels K, Van Cleemput K, Bastiaensens S. Exposure to cyberbullying as a bystander: an investigation of desensitization effects among early adolescents. *Comput Human Behav.* (2016) 62:480–7. doi: 10.1016/j.chb.2016.04.022

28. Bastiaensens S, Pabian S, Vandebosch H, Poels K, Van Cleemput K, Desmet A. From normative influence to social pressure : how relevant others affect whether bystanders join in cyberbullying *Soc Dev.* (2016) 25:193–211. doi: 10.1111/sode.12134

29. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* (2021) 372:n71. doi: 10.1136/bmj.n71

30. Desmet A, Bastiaensens S, Cleemput Van K, Poels K, Vandebosch H. The efficacy of the Friendly Attac serious digital game to promote prosocial bystander behavior in cyberbullying among young adolescents: a cluster-randomized controlled trial. *Comput Human Behav.* (2018) 78:336–47. doi: 10.1016/j.chb.2017.10.011

31. Bastiaensens S, Vandebosch H, Poels K, Van Cleemput K, DeSmet A, De Bourdeaudhuij I. Cyberbullying on social network sites: An experimental study into bystanders' behavioural intentions to help the victim or reinforce the bully. *Comput Hum Behav.* (2014) 31:259–71. doi: 10.1016/j.chb.2013.10.036

32. Bastiaensens S, Vandebosch H, Poels K, Van Cleemput K, Desmet A, Bourdeaudhuij D, et al. I afford to help? How affordances of communication modalities guide bystanders' helping intentions towards harassment on social network sites. *Behav Inf Technol.* (2015) 34:425–35. doi: 10.1080/0144929X.2014.983979

33. Liu C-H, Yin X-R, Huang P-S. Cyberbullying: Effect of emergency perception on the helping tendencies of bystanders. *Telemat Informatics.* (2021) 62:101627. doi: 10.1016/j.tele.2021.101627

34. Jungert T, Holm K, Iotti NO, Longobardi C. Profiles of bystanders ' motivation to defend school bully victims from a self - determination perspective. *Aggress Behav.* (2020) 47:78–88. doi: 10.1002/ab.21929

35. Jungert T, Perrin S. Trait anxiety and bystander motivation to defend victims of school bullying. *J Adolesc.* (2019) 77:1–10. doi: 10.1016/j.adolescence.2019.10.001

36. Ouvrein G, Pabian S, Machimbarrena JM, Erreygers S, De Backer CJ, Vandebosch H. Setting a bad example: Peer, parental, and celebrity norms predict celebrity bashing. *J Early Adolesc.* (2018) 39:937–61. doi: 10.1177/0272431618797010

37. Law DM, Shapka JD, Hymel S, Olson BF, Waterhouse T. The changing face of bullying : an empirical comparison between traditional and internet bullying and victimization. *Comput Human Behav.* (2012) 28:226–32. doi: 10.1016/j.chb.2011.09.004

38. Royen KV, Poels K, Vandebosch H, Zaman B. Think twice to be nice? A user experience study on a reflective interface to reduce cyber harassment on social networking sites. *Int J Bully Prevent.* (2021) 4:23–34. doi: 10.1007/s42380-021-00101-x

39. Vandoninck S, d'Haenens, L. Children's online coping strategies: Rethinking coping typologies in a risk-specific approach. *J Adolesc.* (2015) 45:225–36. doi: 10.1016/j.adolescence.2015.10.007

40. Schultze-Krumbholz A, Zagorscak P, Hess M, Scheithauer H. The influence of school climate and empathy on cyberbystanders' intention to assist or Defend in cyberbullying. *Int J Bully Prevent.* (2019) 2:16–28. doi: 10.1007/s42380-019-00040-8

41. Erreygers S, Pabian S, Vandebosch H, Baillien E. Helping behavior among adolescent bystanders of cyberbullying: The role of impulsivity. *Learn Individ Differ.* (2016) 48:61–7. doi: 10.1016/j.lindif.2016.03.003

42. Barlińska J, Szuster A, Winiewski M. Cyberbullying among adolescent bystanders: Role of the communication medium, form of violence, and empathy. *J Commun Appl Soc Psychol.* (2012) 23:37–51. doi: 10.1002/casp.2137

43. Van Cleemput K, Vandebosch H, Pabian S. Personal characteristics and contextual factors that determine "helping," "joining in," and "doing nothing" when witnessing cyberbullying. *Aggress Behav.* (2014) 40:383–96. doi: 10.1002/ab.21534

44. Panumaporn J, Hongsanguansri S, Atsariyasing W, et al. Bystanders' behaviours and associated factors in cyberbullying. *Gen Psychiatry.* (2020) 33:e100187. doi: 10.1136/gpsych-2019-100187

45. Wang S, Kim KJ. Effects of victimization experience, gender, and empathic distress on bystanders' intervening behavior in cyberbullying. *Soc Sci J.* (2021) 1–10. doi: 10.1080/03623319.2020.1861826

46. Machackova H, Dedkova L, Sevcikova A, Cerna A. Bystanders' supportive and passive responses to cyberaggression. *J Sch Violence.* (2018) 17:99–110. doi: 10.1080/15388220.2016.1222499

47. Schultze-Krumbholz A, Hess M, Pfetsch J, Scheithauer H. Who is involved in cyberbullying? Latent class analysis of cyberbullying roles and their associations with aggression, self-esteem, and empathy. *Cyberpsychology.* (2018) 12. doi: 10.5817/CP2018-4-2

48. Balakrishnan V. Actions, emotional reactions and cyberbullying – From the lens of bullies, victims, bully-victims and bystanders among Malaysian young adults. *Telemat Informat.* (2018) 35:1190–200. doi: 10.1016/j.tele.2018.02.002

49. Chan NN, Ahrumugam P, Scheithauer H, Schultze-Krumbholz A, Ooi PBA. hermeneutic phenomenological study of students' and school counsellors' "lived experiences" of cyberbullying and bullying. *Comput Educ.* (2020) 146:103755. doi: 10.1016/j.compedu.2019.103755

50. Bauman S, Yoon J, Iurino C, Hackett L. Experiences of adolescent witnesses to peer victimization: the bystander effect. (2020) 80:1–14. doi: 10.1016/j.jsp.2020.03.002

51. Olenik-Shemesh D, Heiman T, Eden S. Bystanders' behavior in cyberbullying episodes: active and passive patterns in the context of personal–socio-emotional factors. *J Interpers Violence.* (2017) 32:23–48. doi: 10.1177/0886260515585531

52. DeSmet A, Bastiaensens S, Van Cleemput K, Poels K, Vandebosch H, Cardon G, et al. whether to look after them, to like it, or leave it: a multidimensional analysis of predictors of positive and negative bystander behavior in cyberbullying among adolescents. *Comput Human Behav.* (2016) 57:398–415. doi: 10.1016/j.chb.2015.12.051

53. Machackova H, Pfetsch J. Bystanders ' responses to offline bullying and cyberbullying : the role of empathy and normative beliefs about aggression. *Scand J Psychol.* (2016) 57:169–76. doi: 10.1111/sjop.12277

54. Bussey K, Luo A, Fitzpatrick S, Allison K. Defending victims of cyberbullying : the role of self-efficacy and moral disengagement. *J Sch Psychol.* (2020) 78:1–12. doi: 10.1016/j.jsp.2019.11.006

55. Gahagan K, Vaterlaus JM, Frost LR. College student cyberbullying on social networking sites : conceptualization, prevalence, and perceived bystander responsibility. *Comput Human Behav.* (2016) 55:1097–105. doi: 10.1016/j.chb.2015.11.019

56. Bandura A. *Moral Disengagement: The Encyclopedia of Peace Psychology.* Hoboken, NJ: Blackwell Publishing Ltd. (2011). doi: 10.1002/9780470672532.wbepp165

57. Luo A, Bussey K. The selectivity of moral disengagement in defenders of cyberbullying : contextual moral disengagement. *Comput Human Behav.* (2019) 93:318–25. doi: 10.1016/j.chb.2018.12.038

58. Tong D, Talwar V. Students' moral emotions and judgments of cyberbullying: The influence of previous cyberbullying experiences. *Curr Psychol.* (2020) 41:4200–9. doi: 10.1007/s12144-020-00916-9

59. Patterson LJ, Allan A, Cross D. Adolescent bystanders ' perspectives of aggression in the online versus school environments *. *J Adolesc.* (2016) 49:60–7. doi: 10.1016/j.adolescence.2016.02.003

60. You L, Lee YH. The bystander effect in cyberbullying on social network sites: anonymity, group size, and intervention intentions. *Telemat Informatics.* (2019) 45:101284. doi: 10.1016/j.tele.2019.101284

61. Koehler C, Weber M. "Do I really need to help?!" Perceived severity of cyberbullying, victim blaming,and bystanders' willingness to help the victim. *Cyberpsychology.* (2018) 12. doi: 10.5817/CP2018-4-4

62. Latané B, Darley JM. *The Unresponsive Bystander: Why Doesn't He Help?* New York, NY: Appleton-Century- Croft (1970).

63. Patterson LJ, Allan A, Cross D. Adolescent perceptions of bystanders' responses to cyberbullying. *New Media Soc.* (2017) 19:366–83. doi: 10.1177/14614448156 06369

64. Song J, Oh I. Factors influencing bystanders' behavioral reactions in cyberbullying situations. *Comput Human Behav.* (2018) 78:273–82. doi: 10.1016/j.chb.2017.10.008

65. Levy M, Sela-Shayovitz R. Cyberaggression: The effect of parental monitoring on bystander roles. *Int J Child Youth Fam Stud.* (2020) 11:13–36. doi: 10.18357/ijcyfs114.2202019986

66. Suler J. The online disinhibition effect. *Cyberpsychol Behav.* (2004) 7:321–6. doi: 10.1089/1094931041291295

67. Cram WA, Templier M, Paré G. (Re)considering the concept of literature review reproducibility. *J Assoc Inf Syst.* (2020) 21:1103–14. doi: 10.17705/1jais.00630

68. Costa-Cordella S, Arevalo-Romero C, Parada FJ, Rossi A. Social support and cognition: a systematic review. *Front Psychol.* (2021) 12:1–22. doi: 10.3389/fpsyg.2021.637060

69. Moxey N, Bussey K. Styles of bystander intervention in cyberbullying incidents. Int J Bully Prevent. (2019) 2:6–15. doi: 10.1007/s42380-019-00039-1

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Learnings from user feedback of a novel digital mental health assessment

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Digital mental health interventions (DMHI) have the potential to address barriers to face-to-face mental healthcare. In particular, digital mental health assessments offer the opportunity to increase access, reduce strain on services, and improve identification. Despite the potential of DMHIs there remains a high drop-out rate. Therefore, investigating user feedback may elucidate how to best design and deliver an engaging digital mental health assessment. The current study aimed to understand 1304 user perspectives of (1) a newly developed digital mental health assessment to determine which features users consider to be positive or negative and (2) the Composite International Diagnostic Interview (CIDI) employed in a previous large-scale pilot study. A thematic analysis method was employed to identify themes in feedback to three question prompts related to: (1) the questions included in the digital assessment, (2) the homepage design and reminders, and (3) the assessment results report. The largest proportion of the positive and negative feedback received regarding the questions included in the assessment (n = 706), focused on the quality of the assessment (n = 183, 25.92% and n = 284, 40.23%, respectively). Feedback for the homepage and reminders (n = 671) was overwhelmingly positive, with the largest two themes identified being positive usability (i.e., ease of use; n = 500, 74.52%) and functionality (i.e., reminders; n = 278, 41.43%). The most frequently identified negative theme in results report feedback (n = 794) was related to the report content (n = 309, 38.92%), with users stating it was lacking in-depth information. Nevertheless, the most frequent positive theme regarding the results report feedback was related to wellbeing outcomes (n = 145, 18.26%), with users stating the results report, albeit brief, encouraged them to seek professional support. Interestingly, despite some negative feedback, most users reported that completing the digital mental health assessment has been worthwhile (n = 1,017, 77.99%). Based on these findings, we offer recommendations to address potential barriers to user engagement with a digital mental health assessment. In summary, we recommend undertaking extensive co-design activities during the development of digital assessment tools, flexibility in answering modalities within digital assessment, customizable additional features such as reminders, transparency of diagnostic decision making, and an actionable results report with personalized mental health resources.

KEYWORDS

digital health, mental health, mHealth, user feedback, thematic analysis, composite international diagnostic interview

Introduction

Mental health disorders are among the leading causes of disability worldwide, as indicated by disability-adjusted life-years (1) and are associated with substantial detrimental impacts on the individual (2–4), societal, and economic level (5, 6). The prevalence of mental health disorders is estimated to be rising, with a 21% increase of people accessing mental health services in the United Kingdom between 2016 and 2019 (7), with further reported increases in the wake of the COVID-19 pandemic (8–13). The demands on mental healthcare services are high, with a large number of patients presenting to services, alongside a parallel increase in patients with complex or severe psychiatric symptoms (13, 14). Despite the high prevalence and burden of mental health disorders globally, a lack of adequate recognition of disease and delivery of traditional mental health care persists (15–17) due to barriers such as the high costs and an understaffed work force (14, 18).

Considering these barriers to traditional mental healthcare, digital mental health interventions (DMHI) provide a method to support detection, treatment, and management of psychiatric conditions (16, 19, 20). DMHIs are versatile as they can be integrated in the traditional care pathway, and used alongside in-person care (20–22). Thus, DMHIs and traditional in-person care should be viewed as complementary. DMHIs are able to address geographical and service level barriers to accessing mental health services, such as understaffing and medical coverage of more remote areas (23) providing support to healthcare providers. In return, healthcare providers can facilitate engagement with DMHIs, as evidence shows that two-thirds of individuals prescribed a digital intervention for depressive or anxiety symptoms by their GP reported using it (24). Additionally, DMHIs can address non-service level barriers associated with accessing traditional face-to-face mental health care, such as patients experiencing difficulties or distress in disclosing mental health concerns, or perceived stigmatization (23, 25, 26).

In the context of identification and triage of mental illness, digital screening has the potential to reduce the number of patients who require healthcare appointments by identifying patients who may benefit from signposting to self-help strategies or to digital interventions for management and treatment of symptoms, and do not require high-intensity treatment from a clinician (23). These benefits are compounded by a documented interest in the implementation of digital questionnaires designed for the assessment of mental health disorders. These tools are the second most commonly reported digital tool used by General Practitioners (GPs), with computerized cognitive behavioral therapy (cCBT) reportedly being the most commonly used (27). Importantly, an assessment component of mental health apps is perceived positively within written user reviews for such apps (28).

Perhaps most crucially, when considering possible benefits, digital mental health assessments have been shown to improve identification of mental health disorders (24, 25). Previous work has demonstrated that, of those participants who underwent digital screening for common psychiatric disorders in a primary care setting, a quarter of those identified as experiencing depressive or anxiety symptoms were previously unidentified by their GP. The majority of these previously unidentified patients were experiencing mild to moderate symptom severity, however 1-in-10 presented with severe symptoms or reported current suicidal ideation at the time of screening (24). Additionally, digitized screening may help in removing clinician variability or error by standardizing the questions asked of patients when assessing psychiatric symptoms (29, 30). Furthermore, screening ensures that differential mental health conditions are considered during more comprehensive psychiatric assessments. For instance, evidence indicates that most patients with bipolar disorder seek help during depressive rather than manic episodes (31). This can result in a major depressive disorder misdiagnosis, and result in inappropriate or ineffective treatment being delivered to the patient. By ensuring that a history of past mania episodes is detected and considered during clinical decision making, patients may be diagnosed earlier and more accurately, and will thus receive effective treatment earlier. This would be a major benefit as research indicates a high rate of mis- and non-identification of mental health diagnoses, with a meta-analysis including 50,731 patients showing that GPs accurately diagnosed only 47 percent of depression patients (32). Evidence also shows that a GP's ability to correctly detect depression varies dependent on symptom severity, with greater difficulty in accurately identifying mild to moderate presentations (33). An even greater rate of mis-diagnosis is observed in bipolar disorder of just under 70 percent, with the majority of patients being mis-diagnosed with unipolar depression (34, 35). This misidentification rate contributes to documented delays of up to 10 years in receiving an accurate diagnosis of bipolar disorder (34–37). Delays to accurate diagnosis are associated with significant costs to the individual, such as a poorer response to treatment (38), and increased risk of both substance misuse (39) and suicide attempts (40, 41). Reducing these delays by implementing accurate screening tools for bipolar disorder into the care pathway could minimize individual suffering associated with misdiagnosis and delays to receiving the correct treatment, as well as conferring cost savings to healthcare systems (42). For these reasons, there is a compelling health, societal, and economic case to be made for mental health assessments that can improve diagnostic accuracy and early identification.

Digital mental health assessments are generally perceived positively by their users. However, despite the promise of DMHIs for both care providers and patients there persists low user engagement and high levels of dropout (43, 44). This has prompted research into reasons for poor user engagement. User attitudes toward and perspectives of digital mental health tools have been investigated via interviews and focus groups (45–49), surveys (50–53), and app user reviews studies (54–58). In a systematic review of 208 studies investigating user engagement with DMHIs, three constructs of engagement factors were identified related to: (1) the user, (2) the program, and (3) the technology and environment (59). Relevant for the current paper are engagement factors related to the program construct, and the technology and environment construct. These engagement constructs include specific potential barriers such as the usability, the impact of the DMHI on the user, and the perceived helpfulness of the DMHI (59). Critically, potential user-centric barriers to user engagement include the perceived usability and usefulness of the DMHI. Understanding user perspectives of digitally delivered mental health tools, for example from feedback or during a co-design process, can ensure that the resulting digital tool is suitable for the target user groups' requirements and preferences (60).

Considering the importance of investigating user perspectives, the current study utilized feedback provided by users from a large-scale pilot study of a novel digital mental health assessment to explore users' perspectives. The data used for the current study was taken from the Delta Study conducted by the Cambridge Centre for Neuropsychiatric Research (CCNR) between April 2018 and February 2020 (61). Briefly, the Delta Study was designed to: (1) identify patients with bipolar disorder from a group of patients misdiagnosed with major depressive disorder (MDD); and (2) improve the accuracy and speed of MDD diagnosis among low mood individuals. During the Delta Study, participants completed a novel digital mental health assessment, with a sub-set further providing dried blood spot samples in order to identify proteomic biomarkers which may differentiate between MDD and bipolar disorder. Those who provided blood spot samples were additionally invited to complete the Composite International Diagnostic Interview 3.0 (CIDI; 62). The CIDI was developed by the World Health Organization with the view to extend the scope to include diagnostic criteria from the International Classification of Disease in order to facilitate international comparative research (62). The CIDI has been demonstrated to have excellent concordance with the SCID for bipolar spectrum disorders (63), whilst simultaneously offering more flexibility regarding delivery than the SCID, as the CIDI can also be delivered by a trained and supervised layperson (64). Therefore, the CIDI was considered an appropriate tool for the objectives of the Delta Study.

Following the completion of the novel digital mental health assessment, participants were sent a non-diagnostic results report which outlined the most likely conditions the participant may be experiencing, based on their answers. After the receipt of this results report, participants were provided a feedback survey designed to collect information on their motivations to engage with such an assessment, their perception of the worthwhileness of completing the assessment, and actionable constructive feedback which can be operationalized by the developers to improve future iterations of the assessment. This feedback represents a wealth of information that can guide future development of digital psychiatric assessments to best drive user engagement. Whilst the feedback survey focused on collecting the participant perspectives of, and areas of future improvement for the novel digital mental health assessment, as well as the Delta Study in general, some users provided un-prompted feedback about the CIDI. Thus, we analyzed the feedback dataset in order to: (1) identify features of the digital mental health assessment which users perceived as either positive or negative; and (2) identify commonly mentioned features of the CIDI delivered via telephone, from any unprompted CIDI feedback. Based upon our findings related to each of these aims, recommendations were devised to offer developers insight into optimizing the user experience of digital self-assessments for mental health.

Materials and methods

Data collection

The data used for the current study were taken from the Delta Study. For a detailed description of the Delta Study methods see Olmert et al. (61).

Recruitment was performed via Facebook advertisements and email mailing lists comprised of individuals who had

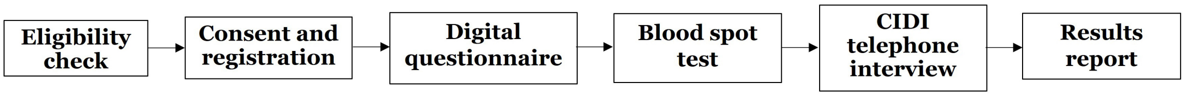


FIGURE 1
Delta Study flow.

consented to be recontacted in the context of previous CCNR studies. During recruitment, participants were familiarized with information regarding the key objectives of the Delta Study in the landing pages outlining the aims, the organizers and funders, the stages of the which the participant would be invited to complete (see **Figure 1** for a breakdown of the flow of the Delta Study), details about what the user can expect to receive following their participation [i.e., a results report with indicated mental health conditions, links to sources of help (SOH) and some brief psychoeducation]. Through a "frequently asked questions" link, the participants were given details about the novel digital assessment including the length of the assessment, the expected time to complete the assessment, and how the mental health symptom data they provide is confidentially stored.

Three groups of patients with current depressive symptoms were recruited into the Delta Study: (1) individuals with no lifetime diagnosis of a mood disorder including MDD and bipolar disorder; (2) individuals with a diagnosis of MDD within the past 5 years and no lifetime diagnosis of bipolar disorder; and (3) individuals with a previous bipolar disorder diagnosis. Inclusion criteria for the Delta Study were: (1) aged 18—45; (2) currently living in the United Kingdom; (3) currently experiencing at least mild depressive symptoms as indicated by a PHQ-9 score of at least 5 (65); (4) no current suicidality; and (5) not currently breastfeeding or pregnant. A total of 5,422 participants were enrolled in the Delta Study. The Delta Study was a three-part study: (1) a digital diagnostic assessment; (2) a dried blood spot collection kit, delivered by post; and (3) Composite International Diagnostic Interview (CIDI) (62), delivered via the telephone. Only participants who returned a dried blood spot sample were invited to participate in the CIDI. Of the enrolled sample, 924 participants completed all three parts of the Delta Study. See **Figure 2** for a breakdown of participant flow through the Delta Study.

Following the eligibility check, consent and registration, participants accessed the Delta Study webpage hosting the novel digital assessment. The digital assessment was developed as a webpage designed for use on both PC and smartphone. The digital assessment was comprised of six separate question sessions: (1) socio-demographics, validated measures including the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS; 66), and psychiatric history; (2) current and past manic and hypomanic symptoms; (3) current and past depressive symptoms; (4) personality traits based on the big five personality framework (66); (5) treatment history, alcohol and substance use; and (6) screening for other psychiatric symptoms. Questions included in question sessions 2, 3, and 6 were based on existing validated measures (62, 67–77) and the expertise of a practicing psychiatrist (SB). Input from a panel of ten patients with lived experience of psychiatric disorders was also implemented when developing the digital assessment. This patient input included review of questions, the results report, and the website and flow of participants through the Delta Study. This patient input resulted in amendment to aspects included in the novel digital assessment (i.e., questions and results report), and participant facing materials included in the Delta Study.

The digital assessment used a logic model which only displayed questions to participants which were relevant based on their previous answers. The potential maximum number of questions answered by a participant was 382, and the average number of questions answered by participants was 284. Upon enrollment, participants were invited to create an account in order to be able to take breaks during the assessment, while automatically saving their progress.

After completion of the digital assessment, participants were sent a brief results report. The results report included: (1) screening results; (2) personalized psychoeducation; (3) a list of SOH; and (4) general self-help tips. The results included in the results report were reached by using a novel algorithm based on the diagnostic rules as set out in the Diagnostic and Statistics Manual of Mental Health Disorders, Fifth Edition (DSM-5; 69).

A feedback questionnaire was available immediately after users completed the digital assessment and after they received their results report. Completion of the feedback questionnaire was optional. The feedback questionnaire was comprised of four closed questions and four open questions designed to gather constructive criticism from users in order to improve future iterations of the digital assessment (see **Table 1**).

Participants were eligible to participate in the CIDI interview if they (1) consented to provide a dried blood spot for biomarker analysis; (2) did not suffer from a blood-borne infectious disease; and (3) had no previous diagnosis of schizophrenia. The dried blood spot collection kit was designed to identify protein biomarkers, previously identified as associated with the psychiatric disorders MDD, bipolar disorder, and schizophrenia (78).

The CIDI was conducted via a telephone call by CIDI-certified interviewers who received continued mentoring and

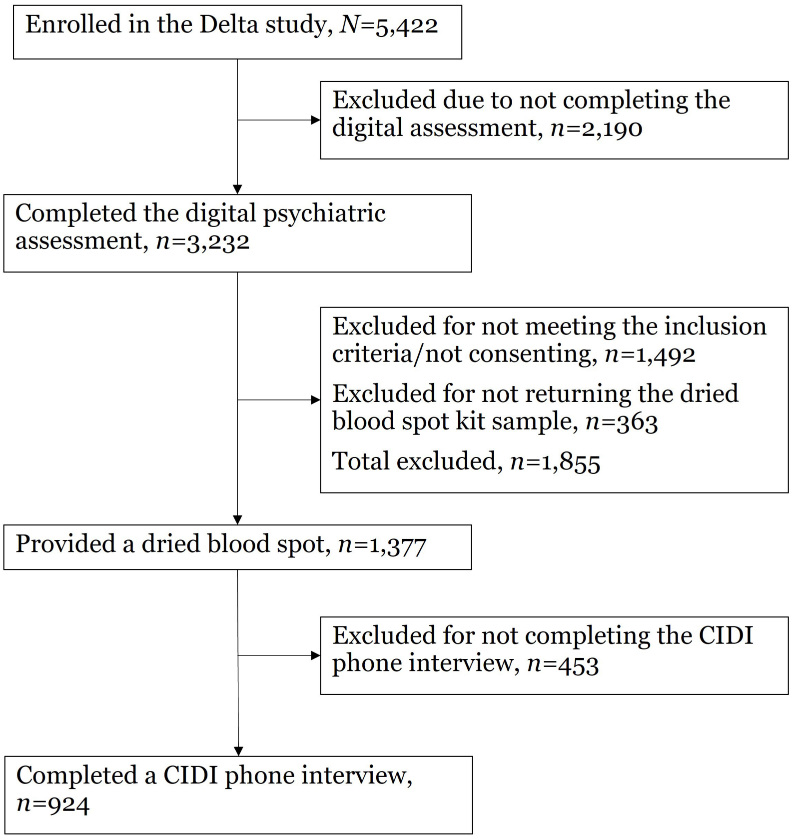


FIGURE 2
Flowchart of participants through the Delta Study.

training. Only the modules required for a lifetime mood disorder diagnosis were offered. There were six possible outcomes of the CIDI interview: bipolar disorder type I, bipolar disorder type II, sub-threshold bipolar disorder, MDD, MDD with subthreshold bipolar disorder, and no mood disorder.

Participants were sent a digital follow-up and usefulness questionnaire at 6 and 12 months after the initial digital mental health assessment. The purpose of the follow-up questionnaire was to investigate help-seeking behaviors since the Delta Study, as well as any changes in mental health diagnosis or psychiatric treatment, and to evaluate the perceived usefulness of participation in the Delta Study. The two validated measures, the WEMWBS (79) and PHQ-9 (65) were included in the initial digital assessment and in both the 6-month and 12-month follow up in order to analyze wellbeing scores and depressive symptoms longitudinally, and to determine whether engaging with a digital assessment was associated with improvements in either of these outcomes.

Data selection

The 40.35% of participants who completed the digital assessment ($n = 1304$) also answered the feedback questionnaire. All the participants who completed the feedback questionnaire were included in the dataset.

As the primary aim of the current study was to use thematic analysis to investigate positive and negatively perceived features of a digital mental health assessment, only feedback questions capturing feedback on the question wording, design and flow, homepage design and reminders, and the results report were included (**Table 1**; questions 3, 4, and 5). The decision was made to exclude general feedback (**Table 1**; question 8) in order to avoid the inclusion of data not specifically commenting on the digital assessment (i.e., general feedback on the Delta Study, information the participant wished to share about their personal mental health). Only feedback about the digital mental health assessment itself was included in the thematic analysis. Therefore, any general feedback about the Delta Study pilot or the blood spot kit was not included in the analysis. Any feedback text which only conveyed a sentiment (i.e., "was good," "I liked it"), or any feedback text which was unclear as to what it was referencing (i.e., "it was smooth" which could refer to the trial itself, the question flow or the assessment design) were considered "Not Applicable" for the current study and were excluded from the thematic analysis.

There were 918 responses to the question about assessment design, 1058 responses to the question about homepage design, and 937 responses to the question about the results report design.

Feedback data on the CIDI was included in the current study only when the feedback was specifically commenting on the interview itself and not its delivery (i.e., the skill of the interviewer, the ease or difficulty of booking the interview). Feedback comments were considered to be referring to the CIDI if they mentioned being read the questions rather than digitally delivered, or included the words: (1) "Telephone;" (2) "Interview;" (3) "Telephone question(s);" (4) "Clinical interview."

TABLE 1 Questions included in the Delta Study feedback questionnaire.

(1) How did you hear about the Delta trial?
  (1) An advert on Facebook
  (2) In a doctor's surgery
  (3) Through my support group
  (4) A family member told me
  (5) A friend told me

(2) In general, did you find participating in the Delta trial to be worthwhile?
  (1) Not at all
  (2) To a small extent
  (3) Somewhat
  (4) Very much so

(3) The questions are essential for our future diagnostic accuracy. Do you have any thoughts about the design, wording or flow of the questions to help us improve them?
  (Free text box)

(4) We want to make the trial process as smooth and easy for you as possible. What did you think of the homepage design and our email reminders?
  (Free text box)

(5) Finding out what you liked or disliked in your results report will help us make it more relevant and helpful. Do you have any comments about your results report?
  (Free text box)

(6) *(only for participants who completed the blood spot kit)* Did you have any issues with the blood spot kit?
  (1) No
  (2) Yes *(If yes – free text box)*

(7) We're interested in what motivated you to take part in the Delta trial. Why did you decide to participate? Select all that apply.
  (1) To contribute to mental health research
  (2) I was curious about the trial
  (3) To learn more about my mental health
  (4) To learn more about my mental health in general

(8) We'd love to hear anything else you'd like to share:
  (Free text box)

Data analysis

Participant characteristics and psychiatric history were gathered by the novel digital mental health assessment utilized in the Delta Study. Descriptive analyses of this information were conducted to determine averages and frequencies, as appropriate. Group differences between Delta Study participants who did and did not provide feedback were calculated. Mann—Whitney U-tests were used to examine group differences in continuous variables because the data were non-normally distributed. Group differences in categorical variables were calculated using chi-square or Fisher exact test.

The thematic analysis was manually conducted in Excel, following the Braun and Clarke framework (80). The feedback comments were read and re-read until the first author (EF) was familiar with them and any initial ideas were noted. Initial codes were created (EF). For feedback about the novel digital assessment, codes were grouped into "positive" and "negative" sentiment groups. For the CIDI, the decision was made not to group codes into sentiment due to the unprompted nature of the feedback which minimizes the amount of data and its representation in the dataset. The codes were added to a coding framework with brief descriptions for each. The feedback comments were then manually allocated codes under blinded conditions (EF/BS/JB) guided by the coding framework. Any inconsistencies in the code allocations between the authors (EF/BS/JB) were discussed until a consensus was reached. In order to reduce review bias and increase the robustness of results, a double independent review approach was utilized. Therefore, all feedback comments included in the thematic analysis received their final coding based on the consensus of at least two independent reviewers.

The identified codes were then grouped into broader themes, independently by two reviewers (EF/BS), which were then discussed with the third reviewer (JB) until consensus was reached.

Once the thematic labeling was finalized and code/theme frequencies had been calculated, the frequency of overlapping themes was calculated in Excel (see **Supplementary material** 2—6). This involved determining which themes were commonly reported together within the user feedback for each question prompt asked.

Results

Demographics

Participants who completed the feedback survey were mostly female (n = 939, 72.01%), with one or more previous diagnosis (n = 1015, 77.84%). 289 (22.16%) participants who completed the feedback survey reported no previous diagnosis. 722 (55.37%) participants who completed the feedback survey reported two or more previous diagnoses. The most commonly reported previous diagnosis of participants who completed the feedback survey was MDD (Table 2). The mean PHQ-9 score of the participants who completed the feedback survey indicates the sample group experienced moderate MDD symptom severity (Table 2).

Analysis of group differences between Delta Study participants who did and did not provide feedback found that the groups did not significantly differ in terms of sex, educational attainment, total WEMWBS score, total PHQ-9 score, or self-rated mental health quality (Table 2). Delta Study participants who provided feedback were significantly older than those who did not provide feedback. There were differences in the psychiatric histories of Delta Study participants who did or did not provide feedback, with a significantly higher proportion of individuals in the group who did not provide feedback reporting a previous diagnosis of MDD, bipolar disorder, social anxiety disorder, an eating disorder, or a personality disorder (Table 2).

Participants additionally provided scores on the level of how worthwhile they considered participating in the Delta Study (Table 1; question 2). The current study determined a mean worthwhileness score of 3.11 (*SD* = 0.83) on a 1 to 4 scale, with a score of 3 translating to the user considering participation in the study to have been at least somewhat worthwhile. Most participants (*n* = 1017; 77.99%) considered completing

TABLE 2 Demographic information about patients who completed the Delta Study feedback questionnaire (*n* = 1304).

	Provided feedback in the Delta Study (*n* = 1304)	Did not provide feedback in the Delta Study (*n* = 1928)	*U*	*P*	*r*	Chi-square (*df*)	φ_c
Age, years							
Mean (SD)	29.53 (7.66)	27.94 (7.11)	1110024.50	<0.001	0.10	N/A	N/A
Sex							
Male, *n* (%)	365 (27.99)	542 (28.11)	N/A	0.940	N/A	0.006 (1)	0.001
Female, *n* (%)	939 (72.01)	1386 (71.89)	N/A		N/A		
Education^{A}							
<GCSE or equivalent, *n* (%)	41 (3.14)	54 (2.80)	N/A	0.680	N/A	2.304 (4)	0.027
GCSE or equivalent, *n* (%)	222 (17.02)	344 (17.84)					
Advanced level or equivalent, *n* (%)	403 (30.90)	555 (28.79)					
Undergraduate degree, *n* (%)	439 (33.67)	678 (35.17)					
Postgraduate degree, *n* (%)	199 (15.26)	297 (15.40)					
WEMWBS							
Mean (SD)	34.66 (7.99)	34.52 (8.08)	1245297.00	0.651	N/A	N/A	N/A
PHQ-9^{B}							
Mean (SD)	14.64 (5.17)	14.77 (5.17)	1240539.50	0.525	N/A	N/A	N/A
Previous diagnosis							
MDD, *n* (%)	959 (73.54)	1275 (66.13)	N/A	<0.001	N/A	20.024 (1)	0.079
Bipolar, *n* (%)	109 (8.36)	121 (6.28)	N/A	0.024	N/A	5.106 (1)	0.040
GAD, *n* (%)	599 (45.94)	826 (42.84)	N/A	0.082	N/A	3.019 (1)	0.031
OCD, *n* (%)	95 (7.29)	131 (6.79)	N/A	0.592	N/A	0.288 (1)	0.009
PD, *n* (%)	136 (10.43)	194 (10.06)	N/A	0.735	N/A	0.114 (1)	0.006
SAD, *n* (%)	264 (20.25)	329 (17.06)	N/A	0.022	N/A	5.254 (1)	0.040
An eating disorder, *n* (%)	110 (8.44)	140 (7.26)	N/A	0.022	N/A	1.503 (1)	0.220
A personality disorder, *n* (%)	140 (10.73)	167 (8.66)	N/A	0.048	N/A	3.894 (1)	0.035
Schizophrenia, *n* (%)	2 (0.15)	8 (0.41)	N/A	0.333	N/A	1.725 (1)	0.023
Self-rated quality of mental health							
Poor, *n* (%)	918 (70.40)	1310 (67.95)	N/A	0.139	N/A	2.185 (1)	0.026
Fair, *n* (%)	321 (24.62)	500 (25.93)	N/A	0.399	N/A	0.712 (1)	0.015
Good, *n* (%)	65 (4.98)	118 (6.12)	N/A	0.171	N/A	1.878 (1)	0.024

GCSE, General Certificate of Secondary Education; MDD, major depressive disorder; GAD, generalized anxiety disorder; OCD, obsessive-compulsive disorder; PD, panic disorder; SAD, social anxiety disorder. ***(A)*** GCSE and Advanced level are academic qualifications taken by secondary education students in the United Kingdom, in the 11th and 13th year of education, respectively. ***(B)*** The PHQ-9 score can be used to indicate the level of depression severity. Scores of 0—4, 5—9, 10—14, 15—19, and 20 or above indicate a severity of minimal, mild, moderate, moderately severe, and severe respectively (65).

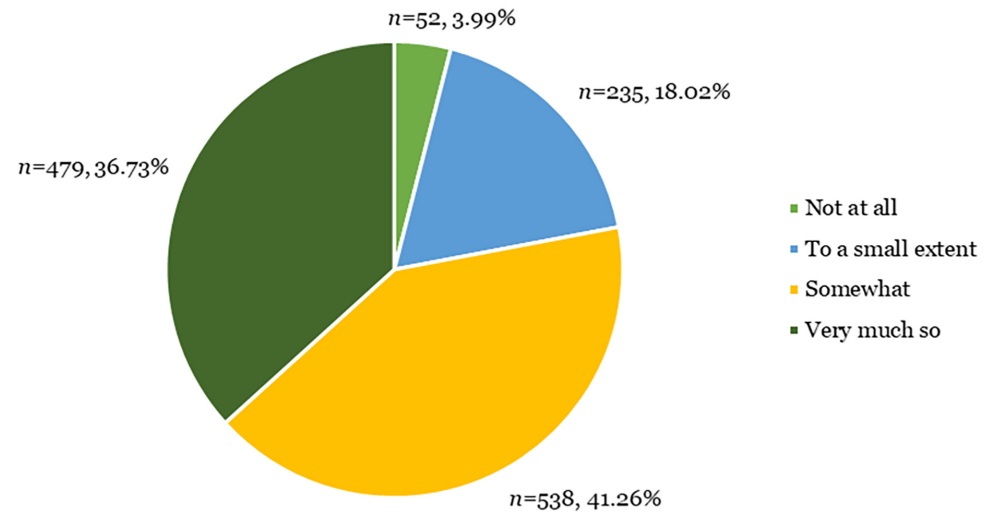


FIGURE 3
Worthwhileness scores from users who provided feedback on the Delta Study (*n* = 1304).

the digital assessment to be at least somewhat worthwhile (**Figure 3**).

Thematic analysis

Example feedback comments presented in the results were extracted from the dataset. The example feedback comments included in the results were taken verbatim from the dataset, so any spelling or grammatical errors are as intended.

Feedback on the design, wording, or flow of the questions

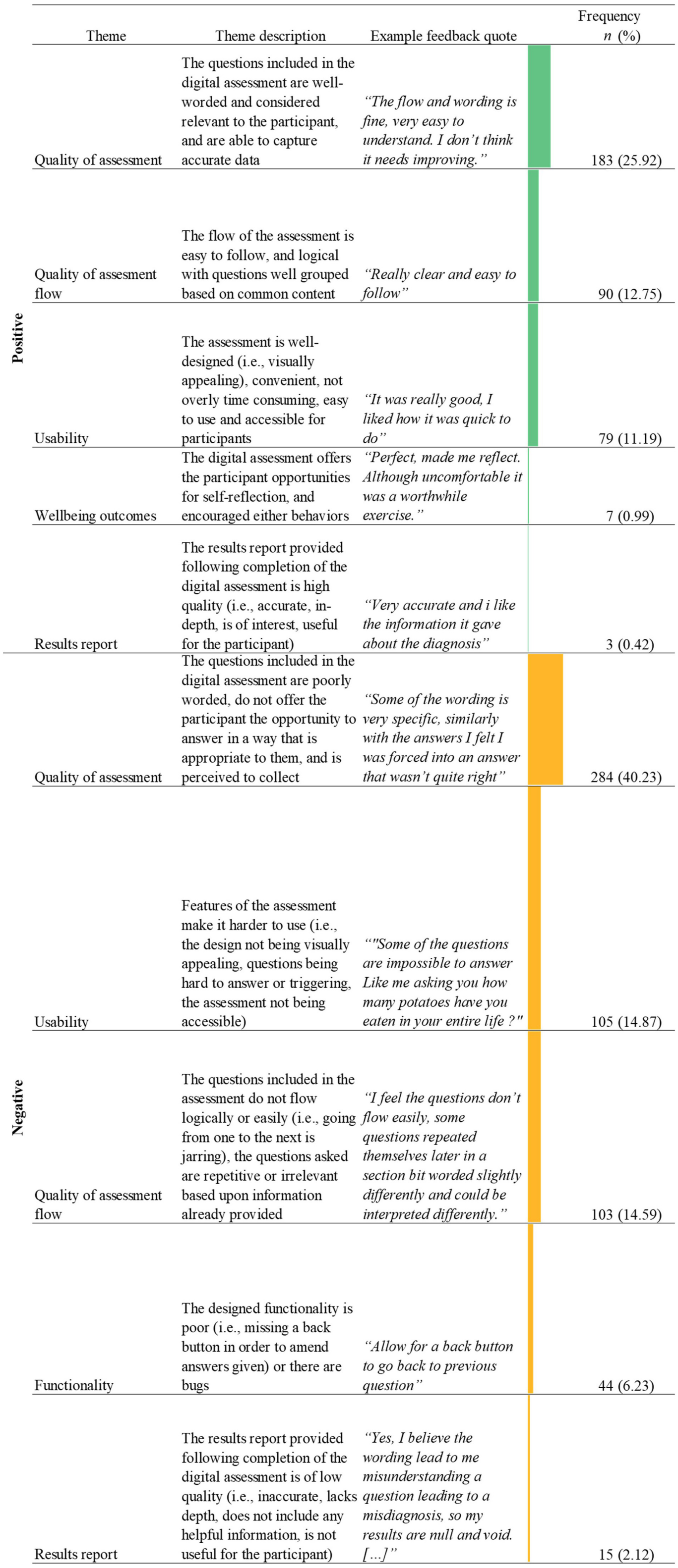
212 (23.09%) responses to the question regarding the design, wording, or flow of the questions were identified as being "Not Applicable" (N/A) to the aims of the current study. This left a total of 706 relevant responses. The average word count of the included feedback for this question was 21.87 (*SD* = 33.89). In total, 10 themes were identified from feedback comments on the design, wording, or flow of questions included in the Delta assessment (See **Figure 4**), including three negative major themes and three positive major themes, focused specifically upon the quality of the assessment content, the quality of the assessment flow, and the usability.

The quality of assessment, related to the question wording, design, or flow (*n* = 467, 66.15%), both positively (*n* = 183, 25.92%) and negatively (*n* = 284, 40.23%), was the most frequently mentioned theme in the feedback. The largest dimension of the negative quality of assessment theme was poorly worded questions (i.e., were too long, overly complicated, lacked clarity; *n* = 150, 52.82%; *"Some of the questions would be a little vague and confusing at times, it could be useful to add an example after the question to explain what is mean")*. A secondary dimension of the negative quality of assessment theme was related to the users' ability to enter an appropriate answer (*n* = 110, 38.78%). This dimension consisted of users reporting missing relevant or accurate answer options, or an inability to select multiple relevant answer options (*n* = 83, 29.23%). Additionally, other users commented on the inability to enter qualitative data (*n* = 27, 9.51%) either in order to provide nuance alongside the answer option they selected, or as a stand-alone method to answer questions. The largest dimension of the positive quality of assessment theme was well worded questions (i.e., easy to comprehend, not overly intrusive; *n* = 175, 95.63%; *"The questions were very straightforward to follow so it was very nice tbh;" "Questions were good, easy to understand and give straight forward answers."*).

Another frequent theme identified in the feedback related to the wording, design and flow of questions was the quality of the assessment flow (*n* = 193, 27.34%; see and **Table 3**), both positive (*n* = 90, 12.74%) and negative (*n* = 103, 14.59%). The most frequently mentioned dimension of the negative quality of assessment flow theme was repetitive questions (*n* = 90, 87.38%; *"Seemed fine, a little repetitive and as a result it felt a little like you were trying to catch me out. Which to be fair is possibly to try to control for recall bias, but the user experience felt a little taxing."*).

Almost all feedback in the positive quality of assessment flow theme referred to a good assessment flow (i.e., easy to follow, logical question flow, well grouped into question sections; *n* = 89, 98.89%; *"I thought the questions flowed very well. I didn't mind doing them at all."*).

The feedback comments also made reference to positive (*n* = 79, 11.19%) and negative (*n* = 105, 14.87%) usability of the assessment. Feedback comments mentioning positive



	Theme	Theme description	Example feedback quote	Frequency *n* (%)
Positive	Quality of assessment	The questions included in the digital assessment are well-worded and considered relevant to the participant, and are able to capture accurate data	*"The flow and wording is fine, very easy to understand. I don't think it needs improving."*	183 (25.92)
	Quality of assesment flow	The flow of the assessment is easy to follow, and logical with questions well grouped based on common content	*"Really clear and easy to follow"*	90 (12.75)
	Usability	The assessment is well-designed (i.e., visually appealing), convenient, not overly time consuming, easy to use and accessible for participants	*"It was really good, I liked how it was quick to do"*	79 (11.19)
	Wellbeing outcomes	The digital assessment offers the participant opportunities for self-reflection, and encouraged either behaviors	*"Perfect, made me reflect. Although uncomfortable it was a worthwhile exercise."*	7 (0.99)
	Results report	The results report provided following completion of the digital assessment is high quality (i.e., accurate, in-depth, is of interest, useful for the participant)	*"Very accurate and i like the information it gave about the diagnosis"*	3 (0.42)
Negative	Quality of assessment	The questions included in the digital assessment are poorly worded, do not offer the participant the opportunity to answer in a way that is appropriate to them, and is perceived to collect	*"Some of the wording is very specific, similarly with the answers I felt I was forced into an answer that wasn't quite right"*	284 (40.23)
	Usability	Features of the assessment make it harder to use (i.e., the design not being visually appealing, questions being hard to answer or triggering, the assessment not being accessible)	*""Some of the questions are impossible to answer Like me asking you how many potatoes have you eaten in your entire life ?"*	105 (14.87)
	Quality of assessment flow	The questions included in the assessment do not flow logically or easily (i.e., going from one to the next is jarring), the questions asked are repetitive or irrelevant based upon information already provided	*"I feel the questions don't flow easily, some questions repeated themselves later in a section bit worded slightly differently and could be interpreted differently."*	103 (14.59)
	Functionality	The designed functionality is poor (i.e., missing a back button in order to amend answers given) or there are bugs	*"Allow for a back button to go back to previous question"*	44 (6.23)
	Results report	The results report provided following completion of the digital assessment is of low quality (i.e., inaccurate, lacks depth, does not include any helpful information, is not useful for the participant)	*"Yes, I believe the wording lead to me misunderstanding a question leading to a misdiagnosis, so my results are null and void. [...]"*	15 (2.12)

FIGURE 4
Name, description, examples, and frequencies of themes as identified in the thematic analysis of feedback responses about the question design, wording, and flow (*n* = 706; See **Supplementary material 1** for novel digital assessment theme count). Bars represent theme frequency as a percentage of the total number of relevant feedback responses (*n* = 706).

TABLE 3 Frequency of theme combinations from thematic analysis of feedback responses about the question design, wording and flow, with ten or more instances in the dataset (n = 706; see Supplementary material 2 for the remaining theme co-occurrences).

Theme combination	Example feedback comment	Frequency (*n*,%)
Negative quality of assessment AND Negative usability	*"I felt some of the statements that I was required to rate how much I agreed with could have been simplified. I found I agreed strongly with one part of the statement but not at all with another part, which made it very hard to rate my level of agreement overall"*	46 (6.52%)
Positive quality of assessment AND Positive quality of assessment flow	*"Questions were worded well and flowed fluidly; I can see no obvious improvements which could be made."*	31 (4.39%)
Negative quality of assessment AND Negative assessment flow	*"Some questions were rather repetitive or confusing in their wording."*	27 (3.82%)
Positive quality of assessment AND Positive usability	*"[. . .] it was easy to access and the questions were easy to understand."*	25 (3.54%)
Positive quality of assessment flow AND Positive usability	*"Worked well for the structure and flow on my mobile phone. Easy log in. [. . .]"*	10 (1.42%)
Negative quality of assessment AND Negative functionality	*"I accidentally selected the incorrect age for one question and it automatically moved into the next question. It would have been helpful to be able to go back and change this.* *Some of the questionnaires were not realistic regarding causes of periods of poor metal health (i.e., Having to confirm a singular cause such as physical)"*	10 (1.42%)

usability features mainly focused on the assessment being well-designed (i.e., visually appealing; n = 42, 53.16%; *"Design of the website/app was very user friendly and smooth. Graphics were easy to understand.")* and ease of use (n = 32, 40.51%; *"Simple and easy to use*"). Most feedback in relation to negative usability focused on the questions being hard to answer (n = 83, 79.05%). In some cases this was linked to the questions being poorly worded (n = 27, 18%; *"I felt some of the statements that I was required to rate how much I agreed with could have been simplified. I found I agreed strongly with one part of the statement but not at all with another part, which made it very hard to rate my level of agreement overall*"), and in other cases it was linked to the lack of ability to select an appropriate answer option (n = 19, 22.89%; *"Sometimes it was difficult to choose between two answers as it was difficult to decide which was most applicable."*). However, some feedback comments cited the reason for difficulty in answering questions being due to, in some part, it being difficult to remember specific depressive or mania episode information (i.e., number of episodes, duration of episodes; n = 23, 27.71%; "*I think it's very difficult to retrospectively our exact lengths of time on things and days per year. Lots of the time I'm not certain about how long I have been feeling things or extreme feelings I have subsided slowly. I also found it a little difficult to determine whether less extreme episodes were still classes as episodes*").

Finally, negative functionality was also identified as a theme within feedback relating to the wording, design, or flow of questions in the digital assessment (n = 44, 6.23%). The vast majority of this feedback commented on the lack of a back button within the digital assessment, or the users missing the ability to review and amend their answers before submitting them for analysis by the algorithm (n = 41, 93.18%). Of users who provided this feedback, 31.71% (n = 13) reported that they were concerned about providing inaccurate data within the assessment as they were unable to amend their answers after choosing one (*"I feel like there should be a back button in case you answer a question incorrectly. At least one of my questions was answered incorrectly and I couldn't change the answer*").

Several themes overlapped within the feedback on the wording, design, and flow of the questions (Table 3). The most frequently overlapping themes were negative perception of quality of assessment and usability (n = 46, 6.52%). The majority of this overlap was between users reporting questions were hard to answer and (1) questions being poorly worded (n = 33, 70.21%; *"Some questions were very broad so quite difficult to answer especially with regards to symptoms."*); (2) reporting an inability to answer appropriately (n = 21, 44.68%; *"Sometimes none of the multiple choice questions described my experiences so it was difficult to answer. Maybe some written/spoken answers more specific to a person would be more helpful."*); or, (3) concerns about reporting inaccurate data (n = 15, 31.91%; *"Sometimes I honestly didn't know how long specific conditions had been going on for or when my first episodes started or how long or how many I had over the years so I had to guess. I think my guesses were probably not even close to correct. There should be more opportunity for 'I don't know know'*").

Other commonly overlapping theme combinations were a positive quality of assessment and the positive quality of assessment flow (n = 31, 4.39%), and a negatively perceived quality of assessment and assessment flow (n = 27, 3.82%; *"It was easy to answer and the questions flowed nicely"*). 24.44% (n = 22) of feedback which mentioned repetitive questions, also stated that questions were poorly worded. Users provided feedback that repetitive questions assessing the same symptom multiple times were worded too similarly, which caused reports of confusion from users (*"Word similar questions* *more contrastingly. Sometimes I didn't know the difference between questions."*).

Positive perception of quality of assessment and usability were also often identified in combination (*n* = 25, 3.54%) with many users commenting on both well-written questions and a well-designed assessment in their feedback (*n* = 23, 92.00%; *"They were laid out clearly and easy to understand"*).

Feedback on the homepage design and email reminders

A total of 671 relevant responses were included in the analysis of feedback on homepage design and email reminders. 389 (36.77%) responses were identified as being not applicable to the aims of the current study. The average word count of the included feedback for this question was 11.81 (*SD* = 11.13).

In total, eight themes were identified from feedback comments on the homepage and reminders included in the Delta assessment (See **Figure 5**), including two positive major themes and two negative major themes, focused upon usability and functionality.

When providing feedback on the homepage and reminders, the majority of feedback made reference to positive usability (**Figure 5**). The largest dimensions of this theme included ease of use (*n* = 307, 45.75%; *"Very helpful and easy to navigate"*) followed by a well-designed homepage (i.e., visually appealing, not overly cluttered, simple; *n* = 298, 44.41%; *"I really like these, the design is simple and attractive"*). There was overlap between the largest dimensions of the positive usability theme, with 122 (24.40%) feedback responses stating that the homepage was both well-designed and easy to use (*"Very user-friendly, uncluttered and straightforward. A+"*). Similarly, the negative usability theme (*n* = 11, 1.64%) was most frequently characterized by a poor design (*n* = 8, 72.73%; *"Good needs to be a little more mobile friendly"*).

In terms of functionality, the majority of feedback focused positively upon the reminders to continue the assessment (*n* = 278, 41.43%). Many users commented that they found the reminders to be helpful as a prompt to encourage them to continue with the assessment if they forgot to complete it (*"The homepage is really easy to navigate and the emails are helpful! Part of my mental health problems do concern forgetting things so they helped."*). In contrast, of those who commented negatively on the email reminders (*n* = 33, 66.00%), users stated that the frequency of the reminders were irritating and made the user feel as if they were being pressured into continuing with the assessment (*"Toom many;" "[. . .] The email reminders are quite frequent which could put some users off, especially if they are in a depressive mood."*). Other reported aspects of negative functionality included the presence of bugs (*n* = 15, 30%; *"The web app looked good. But there are things like being pieces to use portrait mode that stopped me doing things and had to keep putting it in desktop mode on my phone."*) and a missing back button (*n* = 5, 10%; *"The one thing I found annoying was not being able to take a step backward if I made a mistake"*).

Several theme overlaps were identified in feedback related to homepage and reminders (**Table 4**). The most frequently identified theme overlap was between positive functionality and positive usability (*n* = 155, 23.10%). A large proportion of feedback which mentioned positive reminders, also mentioned that the assessment had a well-designed homepage (*n* = 121, 78.06%) and that the homepage was easy to use (*n* = 95, 61.29%).

Feedback on the results report

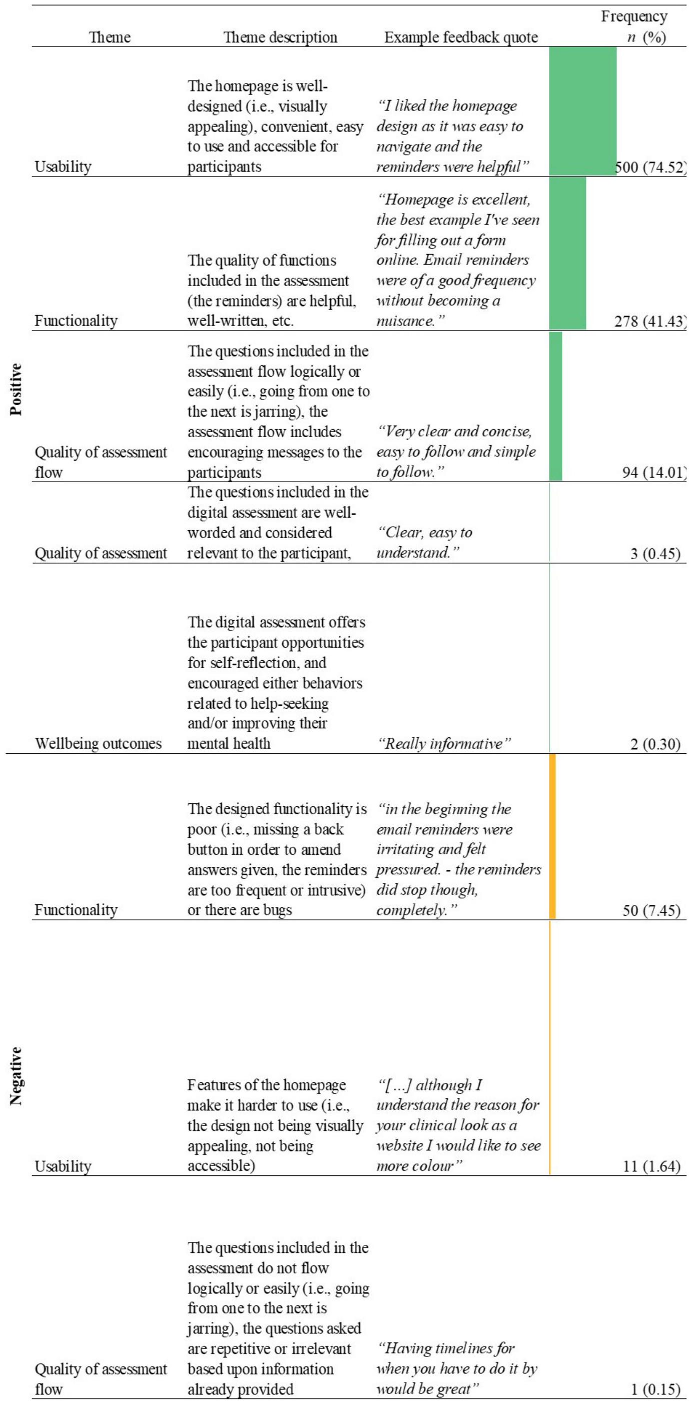
179 (19.10%) responses to the question regarding the results report were identified as being not applicable to the aims of the current study. This left a total of 794 relevant responses. Of the relevant responses, the mean word count of the feedback was 27.85 (*SD* = 31.40).

Through the thematic analysis, 12 themes were identified with three major positive and negative themes (see **Figure 6**).

The most common theme identified within the negative feedback commented on poor report content (*n* = 309, 38.92%), with feedback that the results report lacked depth comprising a major dimension of this theme (*n* = 279, 90.29%). Users reported that the content of the report was too brief (*"I would have liked a little bit more detail."*). An additional common feature of feedback regarding poor report content was a lack of personalization of the report (*n* = 35, 11.33%; *"Not very useful or personal."*). There was an overlap between feedback commenting the results report lacks depth and lacking personalization (*n* = 22, 7.12%; *"It was helpful to gain a diagnosis however I thought the report would be more comprehensive and personalized due to the level of information I provided [. . .]"*).

In contrast, 63 (7.93%) users provided positive feedback regarding the results report's content. The majority of this feedback was centered upon the results report being of an adequate depth, and/or being well-worded (*n* = 54, 85.71%; *"It was very detailed and responsibly worded")*. Users seem to positively comment on results report content when it was concise, detailed, or easy to understand. Of the users who stated that the results report was of adequate depth, and/or was well-worded, many commented that the results report was clear or easy to understand (*n* = 26, 48.15%; *"I found the results report easy to digest and understand. Thank you"*).

The second most commonly identified negative theme in feedback about the results report was negative wellbeing outcomes (*n* = 228, 28.72%). The major tenet associated with negative wellbeing outcomes was related to a lack of diagnostic decision making provided within the report, with many users stated that they wanted more detail on how the results report was reached (*n* = 128, 56.14%; *"Maybe should be clearer that it's not that much information in it though that could be personal to me). I thought there might be more of a*



	Theme	Theme description	Example feedback quote	Frequency *n* (%)
Positive	Usability	The homepage is well-designed (i.e., visually appealing), convenient, easy to use and accessible for participants	*"I liked the homepage design as it was easy to navigate and the reminders were helpful"*	500 (74.52
	Functionality	The quality of functions included in the assessment (the reminders) are helpful, well-written, etc.	*"Homepage is excellent, the best example I've seen for filling out a form online. Email reminders were of a good frequency without becoming a nuisance."*	278 (41.43
	Quality of assessment flow	The questions included in the assessment flow logically or easily (i.e., going from one to the next is jarring), the assessment flow includes encouraging messages to the participants	*"Very clear and concise, easy to follow and simple to follow."*	94 (14.01
	Quality of assessment	The questions included in the digital assessment are well-worded and considered relevant to the participant,	*"Clear, easy to understand."*	3 (0.45)
	Wellbeing outcomes	The digital assessment offers the participant opportunities for self-reflection, and encouraged either behaviors related to help-seeking and/or improving their mental health	*"Really informative"*	2 (0.30)
Negative	Functionality	The designed functionality is poor (i.e., missing a back button in order to amend answers given, the reminders are too frequent or intrusive) or there are bugs	*"in the beginning the email reminders were irritating and felt pressured. - the reminders did stop though, completely."*	50 (7.45)
	Usability	Features of the homepage make it harder to use (i.e., the design not being visually appealing, not being accessible)	*"[...] although I understand the reason for your clinical look as a website I would like to see more colour"*	11 (1.64)
	Quality of assessment flow	The questions included in the assessment do not flow logically or easily (i.e., going from one to the next is jarring), the questions asked are repetitive or irrelevant based upon information already provided	*"Having timelines for when you have to do it by would be great"*	1 (0.15)

FIGURE 5
Name, description, examples, and frequencies of themes as identified in the thematic analysis of feedback responses about the homepage design and reminders (*n* = 671; See **Supplementary material 1** for novel digital assessment theme count). Bars represent theme frequency as a percentage of the total number of relevant feedback responses (*n* = 671).

breakdown of why and how the conclusion was made [. . .]"). A secondary aspect of the negative wellbeing outcomes theme was the user not considering the results report to be useful or to contain any new information about their mental health (*n* = 82, 35.96%; *"It didn't tell me anything new or feel very detailed."*). In some cases, the lack of usefulness or lack of new information was due to a lack of depth in the results report (*n* = 37, 45.19%; *"It was not detailed. I felt I had to*

TABLE 4 Frequency of theme combinations from thematic analysis of feedback responses about the homepage and reminders, with ten or more instances in the dataset ($n = 671$; see Supplementary material 3 for the remaining theme co-occurrences).

Theme combination	Example feedback comment	Frequency (*n*,%)
Positive functionality AND Positive usability	*"I liked the homepage design as it was easy to navigate and the reminders were helpful"*	155 (23.10)
Positive assessment flow AND Positive usability	*"Very easy to follow and get on with"*	36 (5.37)
Positive functionality AND Positive usability AND Negative functionality	*"Very user friendly and easy to use. Emails were helpful, sometimes too often"*	10 (1.49)
Positive functionality AND Positive assessment flow AND Positive usability	*"The website and emails were very well designed; everything was clear and understandable. The questionnaires all worked with no hitches."*	10 (1.49)
Positive usability AND Negative functionality	*"worked well - nice that you can use it on a phone. an auto forward to the next question would be good, as well as the ability to go back to the previous question incase of a mistake"*	10 (1.49)

answer a lot of personal questions just to receive a very generic response. It didn't tell me anything i didn't already know."). Additionally, within the negative wellbeing outcomes theme were comments stating that the results report was missing SOH or psychoeducation, or that the quality of these resources was low ($n = 32$, 14.04%; *"[. . .] information about the conditions that the questionnaire may have confirmed would have been welcome and more contacts for support, help and/or guidance would have been superb."*).

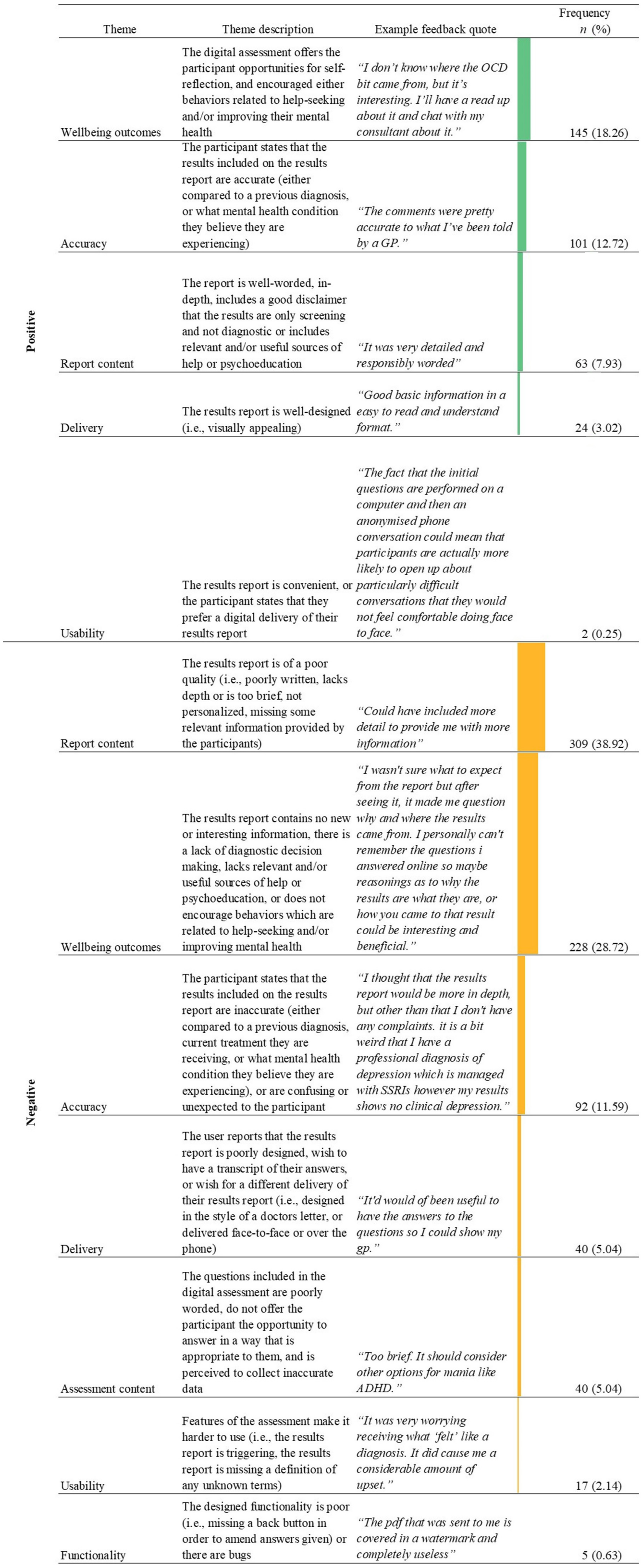
Conversely, other users reported positive wellbeing outcomes ($n = 145$, 18.26%), the biggest dimension of which was the results report encouraging help-seeking or more health-conscious behaviors in users ($n = 57$, 39.31%). Most users commented on the results report's ability to encourage help-seeking with users stating they planned to discuss their results with a clinician (*"Enlightening. I will be taking a trip to a GP."*). Other users additionally stated that they thought the results report would help them initiate conversations with the clinician (*"It contained information that I had suspected for a little while. I may have more confidence to talk with my GP in further detail about my feelings now and explore further diagnoses."*). In addition to saying that the results report encouraged help-seeking, a subset of these users ($n = 5$, 35.17%) stated that the results report was interesting to them or was useful in undisclosed ways (*"It was very simple, but it was useful to me to know that I don't seem to meet the criteria for bipolar."*

Users who mentioned positive wellbeing outcomes also provided feedback on SOH or psychoeducation ($n = 29$, 20.00%), stating that they considered it to be helpful and relevant (*"It was helpful to have help sources identified"*). Of people who noted that the results report contained high-quality SOH or psychoeducation, an equal proportion ($n = 7$, 24.14%) stated that the results report was well-worded (*"The results were presented well and easy to understand, I thought the additional support groups were a great idea."*) or poorly worded (*"I feel like the results report wasn't as comprehensive as I thought it would be. I thought it would be a bit more in depth. However, I think the suggestions on where to seek help and support is very good."*).

Perceived accuracy was a major theme identified in feedback related to the results report, with users comparing the mental health conditions listed on their results report against either a previous formal (*"Is the same results as a psychiatrist had come up with, in my case it was very accurate."*) or a self-suspected diagnosis (*"The results report helps me confirm the symptoms I suspect myself to have had."*). More feedback was identified as commenting on the perceived accuracy of the results report ($n = 101$, 12.72%; *"Results report reiterated my diagnoses from my psychiatrist"*) than perceived inaccuracies of the results report ($n = 92$, 11.59%). The theme of negative accuracy was broader than that of positive accuracy however, encompassing both inaccuracy in the report ($n = 62$, 67.39%) and unexpected or confusing results on the report ($n = 36$, 39.13%), with these dimensions of negative accuracy theme overlapping ($n = 14$, 38.89%; *"Confused as I have been diagnosed bipolar but the results said I'm not"*).

The most frequent theme combination identified in relation to the results report were the negative report content and negative wellbeing outcome themes (Table 5). This theme overlap was frequently identified when users mentioned that the results report was both too brief and was missing information related to the algorithm's diagnostic decision making (i.e., how a specific condition outcome was reached; $n = 42$; 64.62%; *"I found it too simple. I was hoping for more detail as to why these conclusions had been drawn."*). Additionally, some feedback stated that due to the brief content of the results report it did not provide any new information beyond what users already knew about their mental health ($n = 37$, 56.92%;*"The results report was a bit brief; it didn't really tell me anything I didn't already know/suspect."*). Finally, some feedback stated that the brief results report precluded users from help-seeking by not having enough detail in order to present it to a clinician ($n = 5$, 7.69%;*"It wasn't at all as detailed as I thought it would be. I thought there would be an analysis of my answers not just 'you might have depression' and 'you might have a panic disorder.' I was hoping to take my report to my GP to help with getting and accurate diagnosis for my poor mental health but I feel the report will be useless."*).

The themes of positive accuracy and positive wellbeing outcomes were also commonly identified in combination ($n = 18$, 2.27%). Much of the feedback which reported both



	Theme	Theme description	Example feedback quote	Frequency n (%)
Positive	Wellbeing outcomes	The digital assessment offers the participant opportunities for self-reflection, and encouraged either behaviors related to help-seeking and/or improving their mental health	*"I don't know where the OCD bit came from, but it's interesting. I'll have a read up about it and chat with my consultant about it."*	145 (18.26)
	Accuracy	The participant states that the results included on the results report are accurate (either compared to a previous diagnosis, or what mental health condition they believe they are experiencing)	*"The comments were pretty accurate to what I've been told by a GP."*	101 (12.72)
	Report content	The report is well-worded, in-depth, includes a good disclaimer that the results are only screening and not diagnostic or includes relevant and/or useful sources of help or psychoeducation	*"It was very detailed and responsibly worded"*	63 (7.93)
	Delivery	The results report is well-designed (i.e., visually appealing)	*"Good basic information in a easy to read and understand format."*	24 (3.02)
	Usability	The results report is convenient, or the participant states that they prefer a digital delivery of their results report	*"The fact that the initial questions are performed on a computer and then an anonymised phone conversation could mean that participants are actually more likely to open up about particularly difficult conversations that they would not feel comfortable doing face to face."*	2 (0.25)
Negative	Report content	The results report is of a poor quality (i.e., poorly written, lacks depth or is too brief, not personalized, missing some relevant information provided by the participants)	*"Could have included more detail to provide me with more information"*	309 (38.92)
	Wellbeing outcomes	The results report contains no new or interesting information, there is a lack of diagnostic decision making, lacks relevant and/or useful sources of help or psychoeducation, or does not encourage behaviors which are related to help-seeking and/or improving mental health	*"I wasn't sure what to expect from the report but after seeing it, it made me question why and where the results came from. I personally can't remember the questions i answered online so maybe reasonings as to why the results are what they are, or how you came to that result could be interesting and beneficial."*	228 (28.72)
	Accuracy	The participant states that the results included on the results report are inaccurate (either compared to a previous diagnosis, current treatment they are receiving, or what mental health condition they believe they are experiencing), or are confusing or unexpected to the participant	*"I thought that the results report would be more in depth, but other than that I don't have any complaints. it is a bit weird that I have a professional diagnosis of depression which is managed with SSRIs however my results shows no clinical depression."*	92 (11.59)
	Delivery	The user reports that the results report is poorly designed, wish to have a transcript of their answers, or wish for a different delivery of their results report (i.e., designed in the style of a doctors letter, or delivered face-to-face or over the phone)	*"It'd would of been useful to have the answers to the questions so I could show my gp."*	40 (5.04)
	Assessment content	The questions included in the digital assessment are poorly worded, do not offer the participant the opportunity to answer in a way that is appropriate to them, and is perceived to collect inaccurate data	*"Too brief. It should consider other options for mania like ADHD."*	40 (5.04)
	Usability	Features of the assessment make it harder to use (i.e., the results report is triggering, the results report is missing a definition of any unknown terms)	*"It was very worrying receiving what 'felt' like a diagnosis. It did cause me a considerable amount of upset."*	17 (2.14)
	Functionality	The designed functionality is poor (i.e., missing a back button in order to amend answers given) or there are bugs	*"The pdf that was sent to me is covered in a watermark and completely useless"*	5 (0.63)

FIGURE 6

Name, description, examples, and frequencies of themes as identified in the thematic analysis of feedback responses about the results report (*n* = 794; See **Supplementary material 1** for novel digital assessment theme count). Bars represent theme frequency as a percentage of the total number of relevant feedback responses (*n* = 794).

TABLE 5 Frequency of theme combinations from thematic analysis of feedback responses about the results report, with ten or more instances in the dataset (n = 794; see Supplementary material 4 for the remaining theme co-occurrences).

Theme combination	Example feedback comment	Frequency (n,%)
Negative report content AND Negative wellbeing outcomes	*"I think it would be more interesting and helpful to have a more comprehensive report on the results. I agree it wouldn't be right to give a diagnosis this way but more information on how you came to your conclusions and more in depth knowledge for my GP would be helpful."*	65 (8.19)
Positive accuracy AND Positive wellbeing outcomes	*"With my results I can now go to my doctors and explain what i did as the report seems to be correct as it has highlighted something that we mentioned before to the doctors"*	18 (2.27)
Negative assessment content AND Negative accuracy	*"As I said about the questions this meant you don't get a true picture of me thus you can't give a correct analysis of me."*	18 (2.27)
Negative wellbeing outcomes AND Positive accuracy	*"Results report wasn't particularly helpful to me as I'm already being treated for depression. However it did confirm what I already knew"*	10 (1.26)

positive accuracy and positive wellbeing outcomes, indicated that the results report was useful or interesting (n = 10, 55.56%; *"Useful to know, confirms a suspicion I've had for a while."*). An additional proportion of feedback which mentioned positive accuracy and positive wellbeing outcomes in combination mentioned that the results report encouraged help seeking behaviors (i.e., encouraged users to take their results report to discuss with a clinician; n = 8, 44.45%).

The negative assessment content and negative accuracy themes were also identified frequently in combination (n = 18, 2.27%), with users stating that the results included in the report were inaccurate due to the assessment omitting relevant information (i.e., a more in-depth assessment of past psychiatric history, how well medication is managing their psychiatric symptoms, information about menstruation and its impact on the user's mental health, other diagnosed mental health conditions the user has which may be misidentified as a different condition by the algorithms; n = 17; 94.45%; *"The report I was given tells me I am bipolar when in fact I am menopausal which give similar symptoms at times."*).

Some feedback commenting on the positive accuracy of the results report also commented on negative wellbeing outcomes, with users reporting that the results report was useless or lacked any new information as it confirmed a previous diagnosis (n = 18; 21.95%; *"I would've liked more detail in my results. I already knew I had bipolar and anxiety, I like that there was information attached but it was very generic. It would've been nice to see if I had particular tendencies that would respond to certain types of help more than others."*).

Feedback on the composite international diagnostic interview

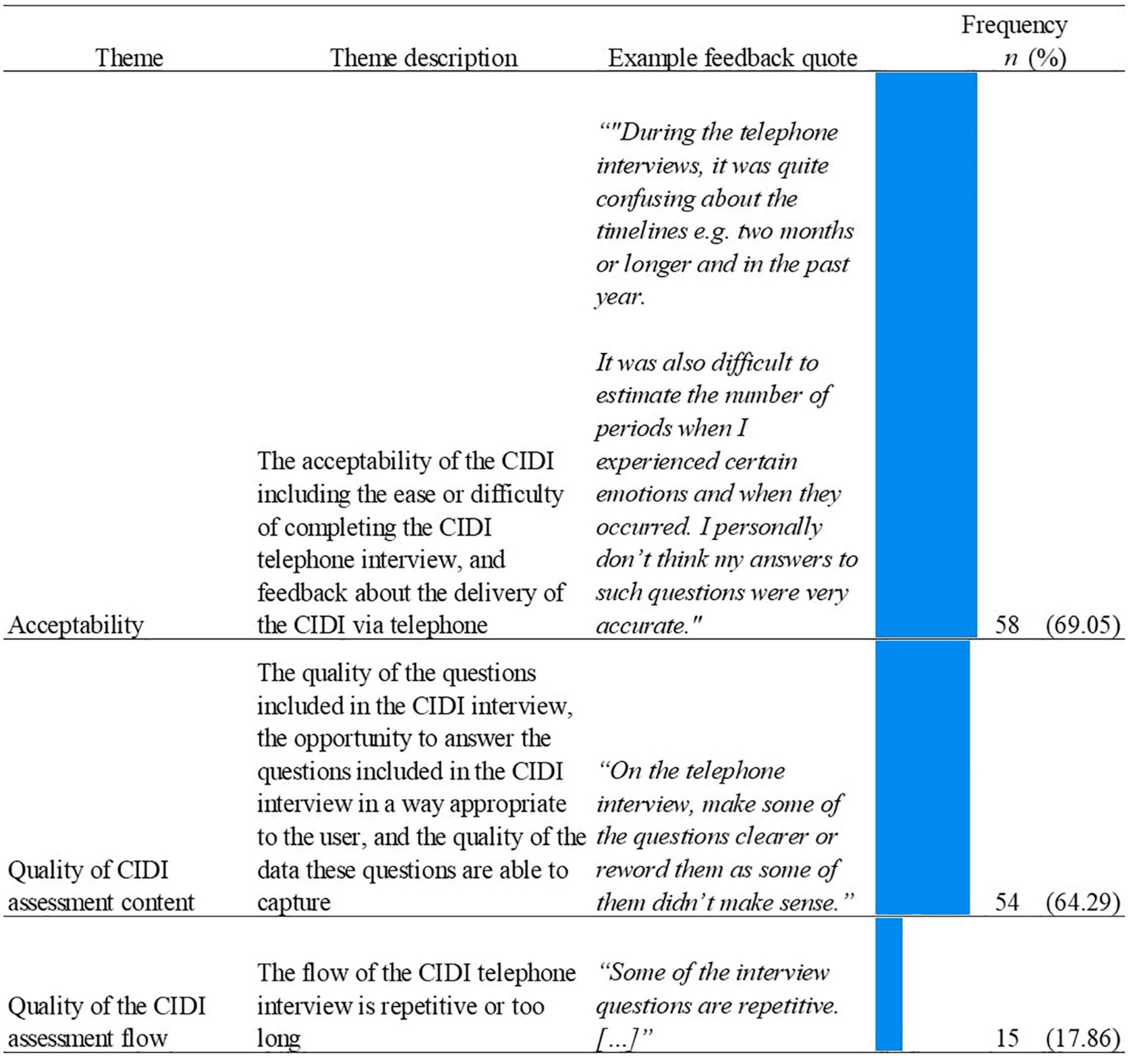
A total of 84 feedback responses mentioned the CIDI unprompted, across all three of the feedback question prompts. 81 (96.43%) of the CIDI feedback was in response to the prompt about the design, wording, or flow of the questions mentioned the CIDI.

Three themes were identified from the thematic analysis of feedback comments which mentioned the CIDI telephone interview (Figure 7).

The most frequently identified theme related to the CIDI was the acceptability of the CIDI telephone interview (n = 58, 69.05%). The most frequently mentioned dimension of this theme was the CIDI containing hard to answer questions (n = 39; 67.24%; *"[. . .] It is also quite difficult to recall in the moment specific (or first) episodes and exactly how long they lasted."*). A secondary dimension was related to the delivery of the CIDI via a telephone call, with users stating they would have preferred a different delivery (n = 14, 24.14%; *"The phone interview was extremely long and could have been done via online. [. . .]"*). Of those users who stated they would have preferred a different delivery, some commented a preference for completing the CIDI on an online platform (*"The telephone survey could have been done online. It would have made it easier for me to think back to historic episodes.[. . .]"*) or requesting the ability to view a copy of the questions before or during the phone interview (*"The wording of the questions was okay, but it may have been beneficial as a participant to have a copy of the interview questions and answers."*).

The acceptability theme was closely followed by the theme of the quality of CIDI assessment flow (n = 54, 64.29%). The majority of feedback within this theme was negative, with a focus on poorly worded questions (n = 32, 59.26%; *"The questions in the phone call are far too long to keep a high level of focus"*) and users reporting concerns that the CIDI was collecting inaccurate information (n = 17, 31.48%; *"A lot of the clinical telephone questions were very hard to answer accurately, e.g., asking for exact numbers of depressive and high episodes, for exact lengths of each episode, to rate exact numbers for hours of sleep etc., and a lot of the questions were difficult to give just a yes or no answer to"*).

Finally, of the users who provided feedback on the CIDI, 15 (17.68%) commented on the quality of the interview flow. Similarly to the digital assessment, many of the users who provided feedback on the



Theme	Theme description	Example feedback quote	Frequency n (%)
Acceptability	The acceptability of the CIDI including the ease or difficulty of completing the CIDI telephone interview, and feedback about the delivery of the CIDI via telephone	*“"During the telephone interviews, it was quite confusing about the timelines e.g. two months or longer and in the past year.* *It was also difficult to estimate the number of periods when I experienced certain emotions and when they occurred. I personally don’t think my answers to such questions were very accurate."*	58 (69.05)
Quality of CIDI assessment content	The quality of the questions included in the CIDI interview, the opportunity to answer the questions included in the CIDI interview in a way appropriate to the user, and the quality of the data these questions are able to capture	*“On the telephone interview, make some of the questions clearer or reword them as some of them didn’t make sense.”*	54 (64.29)
Quality of the CIDI assessment flow	The flow of the CIDI telephone interview is repetitive or too long	*“Some of the interview questions are repetitive. [...]”*	15 (17.86)

FIGURE 7
Name, description, examples, and frequencies of themes as identified in the thematic analysis of unprompted feedback responses about the CIDI (*n* = 84; See **Supplementary material 5** for CIDI theme count). Bars represent theme frequency as a percentage of the total number of relevant feedback responses (*n* = 84).

flow stated that the questions asked were repetitive (*n* = 10, 66.675; *“Phone interview quite repetitive”*). Additionally, users also commented that the CIDI interview was too long (*n* = 6, 40.00%; *“Clinical interview is too long.”*).

Only two themes were frequently identified in combination within unprompted feedback regarding the CIDI (**Table 6**). The themes of quality of assessment and acceptability were identified more frequently in combination (*n* = 32, 38.10%) than in isolation (*n* = 19, 22.62%; and *n* = 18, 21.43% respectively). Within this theme overlap, the majority of feedback stated that the questions were both poorly worded and hard to answer (*n* = 10, 52.63%;*“Some questions were too broad up to interpretation and were hard to answer as it wasn’t clear what the exact question was and the phone interviewer is unable to explain further”*).

Discussion

Overview

The primary aim of the current study was to utilize thematic analysis methods of user feedback in order to determine features of a novel digital health assessment which user perceived as either positive or negative. This aim was conceived with the view to offer recommendations in improving the user experience of digital mental health self-assessments. Feedback indicates that the majority of participants who completed the digital mental health assessment considered it to be worthwhile, with over a third categorizing it as very worthwhile. This finding corroborates previous evidence demonstrating that users find engaging with DMHI to be helpful (81, 82). It also supports research that found, via varied measures, high satisfaction is reported by individuals using mental health apps.

Despite the majority of participants considering the current digital mental health assessment to be worthwhile, the thematic analysis indicates key areas for improvement. Most of the written feedback commenting on both the design, wording and flow of the questions, and the results report was negative. This finding may be explained by the framing of the prompts delivered in the feedback survey. The questions were designed to elucidate actionable, constructive feedback on the digital mental health assessment. Therefore, the written feedback was expected to include feature suggestions to improve the assessment.

Themes identified in feedback of a novel digital mental health assessment

Overall, across all feedback questions, the major themes identified in relation to the digital mental health assessment appeared to be the quality of the assessment, its usability, the quality of the report content, accuracy, and wellbeing outcomes. Additionally, functionality was identified as a minor theme across all of the feedback question prompts.

Within the feedback prompt for the question wording, flow, and design of the questions, two-thirds of the feedback was related to the perceived quality of the assessment. Within this theme, the majority of feedback was negative, indicating that questions included within the assessment were overly complex or too long. This appears to be a feature of both psychiatric assessments investigated in the current study, as this feedback was also identified in relation to the CIDI. This negative sentiment regarding the quality of the questions emerging from this feedback indicates the importance of engaging extensively and widely in Public and Patient Involvement (PPI) activities and co-design. PPI involves research being conducted "with" patients and/or the public in an active participatory relationship, rather than "for" patients and/or the public by researchers (83). PPI work can be widely varied including tasks such as defining research priorities (83), and reviewing the study design (84). Engaging in PPI activities within research is now considered best practice (85), with the combination of expertise through experience of a mental health disorder and expertise through clinical experience suggested to facilitate the best design and provision of mental healthcare services (86). As an example, a co-design of mental healthcare services between staff, patients and carers has been demonstrated to improve the quality of acute care services (87). Of interest to the current study focus, a systematic review mapping the impact of PPI on health and social care research demonstrated that PPI can lead to higher quality of research materials, including improved wording of research questionnaires (88). Including PPI panels in the development of questionnaires can enhance the validity of the questions asked and ensure a comprehensive question set (88). Any opportunity to improve the validity of questions asked in a digital mental health assessment should be pursued, particularly as a systematic review of the validity of digital psychiatric assessment tools is lacking high-quality evidence (24).

Whilst a patient panel was consulted in relation to all aspects of the development of the Delta Study assessment tool prior to the pilot study, and amendments were made to the novel digital assessment and study materials after receiving feedback, the feedback demonstrates there are still areas with scope for improvement. Therefore, by engaging in as much PPI tasks as possible, many different perspectives can be captured in the design stage in order to maximize the likelihood of designing an assessment which is both accessible and usable to all in the intended population. Ensuring the questions are easily comprehended by users who are experiencing mental health symptoms is particularly important when considering possible cognitive/concentration difficulties associated particularly with low mood, MDD (68, 89) and bipolar disorder (90). This is important as previous literature suggests that impaired neurocognitive functioning may be associated with poorer ability to engage in digital health tools for mental health conditions (91). However, it should be noted that this is not isolated to engagement with DMHIs, as in order for patients to engage with traditional care they must also be able to engage in a lengthy diagnostic interview (92). The advantage of DMHIs is that the assessment can be completed at an opportunity most convenient to the user, and when the user feels most concentrated, potentially encouraging better engagement.

Another dimension of the quality of the assessment was related to a reported lack of ability to select appropriate answers.

TABLE 6 Frequency of theme combinations from thematic analysis of unprompted feedback responses about the CIDI, with ten or more instances in the dataset (n = 84; see Supplementary material 6 for the remaining theme co-occurrences).

Theme combination	Example feedback comment	Frequency
CIDI quality of assessment content AND CIDI acceptability	*"They were quite wordy so would have been easier to do online rather than the phone, e.g., in how many separate years have you had had episodes that last for 4 days or longer in which you feel a, b, and c. Would have been easier to have in front of me to reread and be sure I understood and answered correctly."*	32 (38.10)

This was reflected in some users stating that a necessary answer option was missing or that they were unable to choose multiple answer options when needed. Therefore, considering that often symptoms are hard to quantify, only offering pre-defined answer options may make it hard to fully capture the severity and psychological burden. Associated with an inability to select an appropriate answer were concerns that the data collected may be inaccurate as users felt they were encouraged to select the "closest fit" answer option, as the most accurate answer option was not available. Considering the core motivation for completing a digital mental health assessment is likely to be receiving an accurate indication of current mental health status, a perception that inaccurate data is being collected may be a barrier to engagement. Developers should aim to engage users thorough PPI activities to ensure that a large range of answer options are available to users to best allow them to reflect their experiences and symptoms. Additionally, developers may wish to consider offering multiple modalities of answer entry, chiefly open or free text boxes. In the current study, some users requested the ability to enter other datatypes such as free text in order to provide personal context. These free text boxes could be implemented alongside more standardized measures to maintain the collection of necessary data to assess symptom fit against diagnostic criteria. Aside from being a commonly requested feature identified in the current study, the addition of free text would allow for potentially richer data which could be used for additional diagnostic decision making such as during a clinician review of questionnaire data.

Usability is a commonly reported feature of user feedback reported in previous literature (58) and is a potential barrier to usage of digital tools (59). An attractive design and ease of use are the highest rated aspects to user engagement with DMHIs identified in user reviews (27, 92). Both of these dimensions of usability were identified within the current study in relation to feedback on the homepage design and reminders. Ease of use and good visual design were mentioned in the majority of feedback response within the usability theme, and were often identified in combination indicating that high-quality visual design will contribute to ease of use.

Additionally, in the current study we found that usability extends to the question wording, flow and design with some users reporting that the questions were hard to answer, however this is likely not exclusive to only mental health questionnaires. In some cases, the reporting of difficulties in answering questions was due to the questions assessing hard to qualify and quantify psychiatric symptoms, or difficulties in remembering episode details (i.e., frequency and duration of depressive and/or manic episodes, the severity of past symptoms). Within the context of bipolar disorder for example, previous literature demonstrates patients experience difficulties in recall of previous (hypo)manic episodes and symptoms (93, 94). This potential difficulty in providing answers to questions could impact both the engagement with the digital tool and the accuracy of any given results, with some users reporting having to make guesses if they did not have a good recollection of their symptomatology. This is a concern in all deliveries of psychiatric assessments, including in-person, as identification of mental health disorders relies upon the patient's narrative and insight. Future work may consider investigating to what extent a patient's level of insight impacts the accuracy of reporting symptoms, and in turn the assessment outcomes in order to determine to what extent this needs to be controlled for during digital (and indeed in-person) psychiatric assessments.

Functionality, whilst being a minor theme identified in the current study, was highly related to usability in terms of the homepage design and reminders. The major aspect of functionality commented upon in the current study was reminders, with more users positively commenting on the quality of the reminders. This is in line with previous findings, which also found that reminders are perceived as a positive feature of mental health apps (95), and are a commonly requested app feature by users (92). In fact, receiving reminders to interact with a DMHI is also associated with higher engagement (59). Additionally, the inclusion of reminders in apps for mental health may support users who are experiencing cognitive symptoms associated with mental health disorders, primarily poor memory and concentration (68, 89). On the other hand, some users reported that they perceived the reminders to be negative, stating that the reminders were sent too often and became intrusive. Therefore, developers may consider allowing the users to modify the number and frequency of reminders they receive to best meet their personal preferences. This is supported by previous evidence highlighting user preference for customizable reminders (57, 58). Considering that integration of DMHIs into user's daily life is considered a facilitator to engagement (59), providing users with the ability to personalize aspects of the reminders (i.e., number of reminders, the time of day) may encourage engagement.

The quality of the report content was a major theme identified both in a positive and negative context in response to the report feedback prompt. The majority of negative feedback was related to the report lacking adequate depth, with users requesting more symptom details alongside the likely diagnosis indicated by the algorithm to reflect the amount of information they provided during the assessment. Additionally, some users indicated that the results report was lacking personalization. Previous literature demonstrates the importance of personalization from analyses of user reviews (58). Further reports posit that a lack of perceived personalization in DMHIs constitute a barrier to user engagement (59, 96), and that offering personalized feedback increases user engagement (97). Therefore, by ensuring that the report content is personalized to the data provided by the user during the completion of the assessment, engagement may be increased. The constructs of the results report lacking adequate depth and lack of personalization were also identified in combination, with users reporting expectations of the report being an in-depth analysis and personalized to the responses they provided. The importance of personalization is further reflected in the current study, as some users commented that the provided SOH and psychoeducation were a positive feature when perceived to be relevant to their results, and likewise considered a negative wellbeing feature if relevant SOH or psychoeducation was missing.

Conversely, positive report content was centered on the report being well-worded and of an adequate depth. Whilst this was a smaller proportion of provided feedback, it is still of interest that different users can hold different sentiment polarity opinions toward the same report content. Therefore, future work should consider investigating factors related to the level of detail in a mental health results report a user prefers. This would also offer the opportunity to expand the ability for personalization to user preferences, by offering the user their preferred level of report detail. Investigating user-centered factors related to determining the user's preferred level of results report detail is further substantiated by the overlapping themes of poor report content and negative wellbeing outcomes. The current study observed that a perceived lack of detail in the results report was associated with a lack of new or useful information being provided to the user. Future work may wish to investigate whether users with prior knowledge of their own mental health or previous interactions with mental health services may require additional detail as compared to users who do not have such past knowledge or experience. This would assist in ensuring all users are offered meaningful and actionable insights from the results report, irrespective of their prior level of knowledge of their own mental health. In the current study, accuracy was identified as a theme in relation to the results report, with a similar proportion of users perceiving the results as accurate or inaccurate when comparing them to either self-suspected or previous formal mental health diagnoses. Importantly, when assessing accuracy of mental health assessments some users seem to use their own self-suspected diagnosis as a "gold standard." More people now look for information about mental health online and evidence indicates that among individuals who search for a potential diagnosis online, thirty-five percent did not visit a clinician to confirm their diagnosis (98). This suggests that some users potentially utilize a digital psychiatric assessment for confirmation of a self-suspected diagnosis, rather than seeking an assessment from a clinician. The potential dangers associated with self-diagnosis of mental health conditions are a great concern (99), especially if coupled with potential self-medication through illegal online drug providers. Therefore, future work should consider exploring the incidence of users who utilize a self-suspected mental health diagnosis as a gold standard when assessing the accuracy of a digital mental health assessment, or online symptom checker.

The current study demonstrated that completing a digital mental health assessment is associated with both positive and negative wellbeing outcomes, as perceived by users. In terms of positive wellbeing outcomes, the major dimension was related to the receipt of a results report encouraging help-seeking, or facilitating more health conscious behavior to improve their mental health. This finding reflects insights from previous reports demonstrating that engaging in online screening tools increases one's likelihood in seeking mental healthcare or support (82, 100–102). Additionally, some users stated that they considered their results report to be of interest or of non-specified usefulness. This reflects previous work which demonstrates that an increase in mental health understanding and/or responsibility is a commonly identified feature mentioned in app store reviews of mental health apps which offer an assessment. Therefore, whilst some users did not indicate that they took their results report to a clinician to discuss, this aspect of the positive wellbeing outcomes theme suggests that the results report can still offer value outside of a formal healthcare context.

The core dimensions of the negative wellbeing outcomes theme was related to a lack of explanation of diagnostic decision making within the results report. This has also been identified in previous reports in relation to Artificial Intelligence (AI), which highlighted that users of online symptom checkers wish to be provided an explanation for the results reached based upon their personal data (103). Ensuring that users are aware of how results of digital assessments were reached may potentially increase trust, and encourage users to follow personalized triage recommendations (104). This was also reflected in the findings of the current study, which showed that some users reported that the lack of explanation of diagnostic decision making precluded them from or caused hesitation in showing their results report to a clinician.

Themes identified in the composite international diagnostic interview feedback

The most frequent theme identified in feedback on the telephone-delivered CIDI was acceptability. Similar to the feedback for the digital assessment, the current study identified that poor acceptability of the CIDI was also related to the included questions being considered hard to answer by users. Therefore, this further demonstrates that difficult to answer questions are not simply a feature of digital mental health screening tools, and also extend to interviewer-led telephone interviews.

Interestingly, in relation to the theme of acceptability some users stated they would have preferred a digital rather than phone delivery of the CIDI, while the majority did not comment on it. This reflects previous work demonstrating that when a computerized version of the CIDI is delivered, 94 percent of 222 patients in an acute psychiatric setting liked the interview, with a further 60 percent stating that they found the interview just as comfortable or more comfortable than completing an in-person interview with a doctor (105). However, these findings must be evaluated with caution since this previous work was published over 20 years ago and the digital literacy of the population has increased. Similarly, our study was not focused on the CIDI and the feedback gathered in relation to it was incidental; hence, further work is required to investigate the suitability of the CIDI for digital delivery.

The second most frequently identified theme related to the CIDI was the quality of the assessment content. Some users who underwent the CIDI assessment stated that the questions included in the assessment were poorly worded or lacked an appropriate option to provide an accurate answer. Similar to the current study, previous work also identified a lack of suitable answer options as a frequent criticism of the CIDI (105). However, this may be a feature related to the previously stated difficulties of quantifying and qualifying highly heterogenous and subjective mental health symptoms into the "neat" binary categories often employed for data collection with screening tools or in a structured interview. This again highlights the potential benefits conferred by offering users free text modalities to provide additional information as well as using pre-defined questions and answer options to determine fit to diagnostic criteria.

Limitations

Despite the learning offered from the current study, the content and sentiment of the feedback of both the novel digital mental health assessment and CIDI may have been skewed due to several reasons.

Firstly, unfortunately, as the feedback questions were only asked to users who completed the entire digital assessment, and received their results report, no feedback was collected from users who dropped out. Therefore, the feedback sentiment or content may be skewed, and does not capture the reasons of users who have dropped out. However, as we included a large dataset of users who completed the entire digital assessment we have an evidence base demonstrating features which users who completely engaged with a digital mental health assessment considered to be positive or negative. Despite this, future work may consider addressing this by providing all users, even those who drop out, the opportunity to offer feedback. The study cohort only included individuals experiencing symptoms of low mood, or with a previous diagnosis of a mood disorder (i.e., MDD or bipolar disorder). Thus, the findings may not be representative to other patient populations outside the scope of the original pilot study. Therefore, caution should be taken when applying the findings to non-psychiatric users or users with other mental health concerns or disorders. Future work should address these populations, by assessing feedback on the same domains as the current study.

Within the current study, there were no group differences in terms of gender between Delta Study participants who did and did not provide feedback; however, the results of the current analysis of this written feedback should be interpreted with the caveat that the majority of participants were female. There is substantial evidence that, despite disproportionately high rates of suicide in men compared to women (106), men are less likely to seek help or engage in psychiatric treatment either in-person or through DMHIs. This is corroborated by evidence of low rates of help-seeking for mental health concerns in men (107). Some explanations for these low rates of help-seeking include stigma, adversity to appearing "vulnerable," and difficulties in effectively communicating mental health concerns with healthcare professionals (108). Several of the above mentioned barriers to help seeking can be addressed with DMHIs, however the majority of users of such tools appear to be women (59). Future work should investigate which features and delivery methods would encourage men to engage with DMHI's and in turn with mental health support and treatment. The thematic analysis method employed in the current study is potentially susceptible to bias. However, by implementing an independent double review for each piece of feedback and for each identified theme, we aimed to mitigate this risk.

Finally, there was no specific question assessing user perspectives of the CIDI and its mention was incidental. Therefore, the views expressed may not represent the full spectrum of perspectives of individuals who completed the CIDI. This may explain why the feedback given in reference to the telephone-delivered CIDI was overall negative. Future work may wish to investigate user experiences of the CIDI, and opinions toward different modalities of its delivery in order to determine how best to utilize the tool within both clinical and research settings.

Recommendations for improving user engagement

1. Engage in extensive and iterative PPI activities, ensuring a wide range of patient perspectives are captured to establish that questions and associated answer options included in mental health assessments are of an acceptable quality and quantity to both (1) improve user experience, (2) certify the validity and comprehensiveness of the assessment, and (3) enable users who are experiencing cognitive symptoms

associated with mental health disorders to be afforded equal participation opportunities.

2. Consider offering multiple modalities to answer questions within the assessment, such as free text boxes with a view to both (1) increase user engagement; and (2) use this additional data to further inform diagnostic decision making, such as via clinician review.
3. Include reminders to encourage the user to complete their assessment, whilst providing the opportunity for the user to personalize reminder frequency.
4. Consider providing information on the algorithm's diagnostic decision-making logic, to both (1) increase users' trust in the results and (2) increase the likelihood of users sharing their results with a healthcare provider.
5. Ensure that the results provided following a digital mental health assessment are in-depth enough to be actionable by users (i.e., in-depth enough for the user to feel comfortable to share with their healthcare provider), and reflect the amount of time the user has invested to complete their assessment.
6. Provide relevant information, SOH, and psychoeducation which is personalized to the results of the digital mental health assessment.
7. Future work should consider investigating the acceptability of digitally delivered structured diagnostic interviews, such as the CIDI, in light of the current landscape of a more digitally native population.

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/s.

Ethics statement

The studies involving human participants were reviewed and approved by the University of Cambridge Human Biology Research Ethics Committee (approval number HBREC 2017.11). The patients/participants provided their written informed consent to participate in this study.

Author contributions

SB conceived the Delta Study, which provided the data for the current study. EF conceived the focus of the current study. EF was performed the qualitative analysis as first reviewer and BS and JB as the second reviewers. EF prepared the manuscript with revisions from BS, JB, NM-K, TM, GB-O, TO, and SB. All authors contributed to the article and approved the submitted version.

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Conflict of interest

SB is a director of the Psynova Neurotech Ltd., and Psyomics Ltd. EF works as a consultant at Psyomics Ltd. SB and EF have financial interests in the Psyomics Ltd. TO has received payments from the University of Cambridge for licensing of data from the Delta Study.

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.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.1018095/full#supplementary-material

References

1. Murray CJL, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the global burden of disease study 2010. *Lancet.* (2012) 380:2197–223. doi: 10.1016/S0140-6736(12)61689-4

2. Chang C-K, Hayes RD, Perera G, Broadbent MTM, Fernandes AC, Lee WE, et al. Life expectancy at birth for people with serious mental illness and other major disorders from a secondary mental health care case register in London. *PLoS One.* (2011) 6:e19590. doi: 10.1371/journal.pone.0019590

3. De Hert M, Correll CU, Bobes J, Cetkovich-Bakmas M, Cohen D, Asai I, et al. Physical illness in patients with severe mental disorders. I. Prevalence, impact of medications and disparities in health care. *World Psychiatry.* (2011) 10:52–77. doi: 10.1002/j.2051-5545.2011.tb00014.x

4. McManus S, Bebbington P, Jenkins R, Brugha T. *Mental Health and Wellbeing in England: Adult Psychiatric Morbidity Survey 2014*. Leeds: NHS Digital (2016).

5. Vigo D, Thornicroft G, Atun R. Estimating the true global burden of mental illness. *Lancet Psychiatry.* (2016) 3:171–8. doi: 10.1016/S2215-0366(15)00505-2

6. Olesen J, Gustavsson A, Svensson M, Wittchen H-U, Jönsson B. European brain council. The economic cost of brain disorders in Europe. *Eur J Neurol.* (2012) 19:155–62. doi: 10.1111/j.1468-1331.2011.03590.x

7. BMA. *Mental Health Workforce Report*. London: BMA (2022).

8. Office for National Statistics. *Coronavirus and Depression in Adults*. Great Britain: Office for National Statistics (2021).

9. Armitage R. Antidepressants, primary care, and adult mental health services in England during COVID-19. *Lancet Psychiatry.* (2021) 8:e3. doi: 10.1016/S2215-0366(20)30530-7

10. Ettman CK, Abdalla SM, Cohen GH, Sampson L, Vivier PM, Galea S. Prevalence of depression symptoms in US adults before and during the COVID-19 pandemic. *JAMA Netw Open.* (2020) 3:e2019686. doi: 10.1001/jamanetworkopen.2020.19686

11. Xiong J, Lipsitz O, Nasri F, Lui LMW, Gill H, Phan L, et al. Impact of COVID-19 pandemic on mental health in the general population: a systematic review. *J Affect Disord.* (2020) 277:55–64. doi: 10.1016/j.jad.2020.08.001

12. Office for National Statistics. *Are we Facing a Mental Health Pandemic? Are we Facing a Mental Health Pandemic?*. Newport: Office for National Statistics (2021).

13. Nuffield Trust. *What Impact Had Covid-19 had on Mental Health Services?*. (2020). Available online at: https://www.nuffieldtrust.org.uk/news-item/what-impact-has-covid-19-had-on-mental-health-services (accessed July 26, 2022).

14. NHS Providers. *The Demand Challenge*. (2022). Available online at: https://nhsproviders.org/mental-health-services-addressing-the-care-deficit/the-demand-challenge (accessed July 26, 2022).

15. World Health Organization. *Mental Disorders*. Geneva: World Health Organization (2022).

16. Royal College of Psychiatrists. *Public Mental Health Implementation*. London: Royal College of Psychiatrists (2022).

17. Department of Health. *Chief Medical Officer Annual Report 2013: Public Mental Health*. (2014). Available online at: https://www.gov.uk/ (accessed August 01, 2022).

18. BMA. *Measuring Progress: Commitments to Support and Expand the Mental Workforce in England*. London: BMA (2019).

19. Campion J, Javed A, Lund C, Sartorius N, Saxena S, Marmot M, et al. Public mental health: required actions to address implementation failure in the context of COVID-19. *Lancet Psychiatry.* (2022) 9:169–82. doi: 10.1016/S2215-0366(21)00199-1

20. Graham AK, Lattie EG, Powell BJ, Lyon AR, Smith JD, Schueller SM, et al. Implementation strategies for digital mental health interventions in health care settings. *Am Psychol.* (2020) 75:1080–92. doi: 10.1037/amp0000686

21. Aboujaoude E, Gega L, Parish MB, Hilty DM. Editorial: digital interventions in mental health: current status and future directions. *Front Psychiatry.* (2020) 11:111. doi: 10.3389/fpsyt.2020.00111

22. Rayner L, Matcham F, Hutton J, Stringer C, Dobson J, Steer S, et al. Embedding integrated mental health assessment and management in general hospital settings: feasibility, acceptability and the prevalence of common mental disorder. *Gen Hosp Psychiatry.* (2014) 36:318–24. doi: 10.1016/j.genhosppsych.2013.12.004

23. Graham AK, Weissman RS, Mohr DC. Resolving key barriers to advancing mental health equity in rural communities using digital mental health interventions. *JAMA Health Forum.* (2021) 2:e211149. doi: 10.1001/jamahealthforum.2021.1149

24. Whitton AE, Hardy R, Cope K, Gieng C, Gow L, MacKinnon A, et al. Mental health screening in general practices as a means for enhancing uptake of digital mental health interventions: observational cohort study. *J Med Internet Res.* (2021) 23:e28369. doi: 10.2196/28369

25. Martin-Key NA, Schei TS, Barker EJ, Spadaro B, Funnell E, Benacek J, et al. The current state and diagnostic accuracy of digital mental health assessment tools for psychiatric disorders: protocol for a systematic review and meta-analysis. *JMIR Res Protoc.* (2021) 10:e25382. doi: 10.2196/25382

26. Clement S, Schauman O, Graham T, Maggioni F, Evans-Lacko S, Bezborodovs N, et al. What is the impact of mental health-related stigma on help-seeking? A systematic review of quantitative and qualitative studies. *Psychol Med.* (2015) 45:11–27. doi: 10.1017/S0033291714000129

27. Breedvelt JJ, Zamperoni V, Kessler D, Riper H, Kleiboer AM, Elliott I, et al. GPs' attitudes towards digital technologies for depression: an online survey in primary care. *Br J Gen Pract.* (2019) 69:e164–70. doi: 10.3399/bjgp18X700721

28. Oyebode O, Alqahtani F, Orji R. Using machine learning and thematic analysis methods to evaluate mental health apps based on user reviews. *8 IEEE.* (2020) 111:141–58.

29. Bucci S, Schwannauer M, Berry N. The digital revolution and its impact on mental health care. *Psychol Psychother Theory Res Pract.* (2019) 92:277–97. doi: 10.1111/papt.12222

30. Hollis C, Morriss R, Martin J, Amani S, Cotton R, Denis M, et al. Technological innovations in mental healthcare: harnessing the digital revolution. *Br J Psychiatry.* (2015) 206:263–5. doi: 10.1192/bjp.bp.113.142612

31. Bowden CL. A different depression: clinical distinctions between bipolar and unipolar depression. *J Affect Disord.* (2005) 84:117–25. doi: 10.1016/S0165-0327(03)00194-0

32. Mitchell AJ, Vaze A, Rao S. Clinical diagnosis of depression in primary care: a meta-analysis. *Lancet.* (2009) 374:609–19. doi: 10.1016/S0140-6736(09)60879-5

33. Mitchell AJ, Rao S, Vaze A. Can general practitioners identify people with distress and mild depression? A meta-analysis of clinical accuracy. *J Affect Disord.* (2011) 130:26–36. doi: 10.1016/j.jad.2010.07.028

34. Hirschfeld RMA, Lewis L, Vornik LA. Perceptions and impact of bipolar disorder: how far have we really come? Results of the national depressive and manic-depressive association 2000 survey of individuals with bipolar disorder. *J Clin Psychiatry.* (2003) 64:161–74. doi: 10.4088/JCP.v64n0209

35. Fritz K, Russell AMT, Allwang C, Kuiper S, Lampe L, Malhi GS. Is a delay in the diagnosis of bipolar disorder inevitable? *Bipolar Disord.* (2017) 19:396–400. doi: 10.1111/bdi.12499

36. Ghaemi SN, Sachs GS, Chiou AM, Pandurangi AK, Goodwin K. Is bipolar disorder still underdiagnosed? Are antidepressants overutilized? *J Affect Disord.* (1999) 52:135–44. doi: 10.1016/s0165-0327(98)00076-7

37. Lublóy Á, Keresztúri JL, Németh A, Mihalicza P. Exploring factors of diagnostic delay for patients with bipolar disorder: a population-based cohort study. *BMC Psychiatry.* (2020) 20:75. doi: 10.1186/s12888-020-2483-y

38. Hui TP, Kandola A, Shen L, Lewis G, Osborn DPJ, Geddes JR, et al. A systematic review and meta-analysis of clinical predictors of lithium response in bipolar disorder. *Acta Psychiatr Scand.* (2019) 140:94–115. doi: 10.1111/acps.13062

39. Lagerberg TV, Larsson S, Sundet K, Hansen CB, Hellvin T, Andreassen OA, et al. Treatment delay and excessive substance use in bipolar disorder. *J Nerv Ment Dis.* (2010) 198:628–33. doi: 10.1097/NMD.0b013e3181ef3ef4

40. Drancourt N, Etain B, Lajnef M, Henry C, Raust A, Cochet B, et al. Duration of untreated bipolar disorder: missed opportunities on the long road to optimal treatment. *Acta Psychiatr Scand.* (2013) 127:136–44. doi: 10.1111/j.1600-0447.2012.01917.x

41. Altamura AC, Dell'Osso B, Berlin HA, Buoli M, Bassetti R, Mundo E. Duration of untreated illness and suicide in bipolar disorder: a naturalistic study. *Eur Arch Psychiatry Clin Neurosci.* (2010) 260:385–91. doi: 10.1007/s00406-009-0085-2

42. Benacek J, Martin-Key NA, Spadaro B, Tomasik J, Bahn S. Using decision-analysis modelling to estimate the economic impact of the identification of unrecognised bipolar disorder in primary care: the untapped potential of screening. *Int J Bipolar Disord.* (2022) 10:15. doi: 10.1186/s40345-022-00261-9

43. Torous J, Lipschitz J, Ng M, Firth J. Dropout rates in clinical trials of smartphone apps for depressive symptoms: a systematic review and meta-analysis. *J Affect Disord.* (2020) 263:413–9. doi: 10.1016/j.jad.2019.11.167

44. Fleming T, Bavin L, Lucassen M, Stasiak K, Hopkins S, Merry S. Beyond the trial: systematic review of real-world uptake and engagement with digital self-help interventions for depression, low mood, or anxiety. *J Med Internet Res.* (2018) 20:e9275. doi: 10.2196/jmir.9275

45. Lupton D, Maslen S. How women use digital technologies for health: qualitative interview and focus group study. *J Med Internet Res.* (2019) 21:e11481. doi: 10.2196/11481

46. Ribanszki R, Fonseca JAS, Barnby JM, Jano K, Osmani F, Almasi S, et al. Preferences for digital smartphone mental health apps among adolescents: qualitative interview study. *JMIR Form Res.* (2021) 5:e14004. doi: 10.2196/14004

47. Schueller SM, Neary M, Lai J, Epstein DA. Understanding people's use of and perspectives on mood-tracking apps: interview study. *JMIR Ment Health.* (2021) 8:e29368. doi: 10.2196/29368

48. Berry N, Lobban F, Bucci S. A qualitative exploration of service user views about using digital health interventions for self-management in severe mental health problems. *BMC Psychiatry.* (2019) 19:35. doi: 10.1186/s12888-018-1979-1

49. Čuš A, Edbrooke-Childs J, Ohmann S, Plener PL, Akkaya-Kalayci T. "Smartphone apps are cool, but do they help me?": a qualitative interview study of adolescents' perspectives on using smartphone interventions to manage nonsuicidal self-injury. *Int J Environ Res Public Health.* (2021) 18:3289. doi: 10.3390/ijerph18063289

50. Martin-Key NA, Spadaro B, Schei TS, Bahn S. Proof-of-concept support for the development and implementation of a digital assessment for perinatal mental health: mixed methods study. *J Med Internet Res.* (2021) 23:e27132. doi: 10.2196/27132

51. Krebs P, Duncan DT. Health app use among us mobile phone owners: a national survey. *JMIR Mhealth Uhealth.* (2015) 3:e101. doi: 10.2196/mhealth.4924

52. Torous J, Wisniewski H, Liu G, Keshavan M. Mental health mobile phone app usage, concerns, and benefits among psychiatric outpatients: comparative survey study. *JMIR Mental Health.* (2018) 5:e11715. doi: 10.2196/11715

53. Lipschitz J, Miller CJ, Hogan TP, Burdick KE, Lippin-Foster R, Simon SR, et al. Adoption of mobile apps for depression and anxiety: cross-sectional survey study on patient interest and barriers to engagement. *JMIR Mental Health.* (2019) 6:e11334. doi: 10.2196/11334

54. Stawarz K, Preist C, Tallon D, Wiles N, Coyle D. User experience of cognitive behavioral therapy apps for depression: an analysis of app functionality and user reviews. *J Med Internet Res.* (2018) 20:e10120. doi: 10.2196/10120

55. Nicholas J, Fogarty AS, Boydell K, Christensen H. The reviews are in: a qualitative content analysis of consumer perspectives on apps for bipolar disorder. *J Med Internet Res.* (2017) 19:e105. doi: 10.2196/jmir.7273

56. Widnall E, Grant CE, Wang T, Cross L, Velupillai S, Roberts A, et al. User perspectives of mood-monitoring apps available to young people: qualitative content analysis. *JMIR Mhealth Uhealth.* (2020) 8:e18140. doi: 10.2196/18140

57. Stawarz K, Cox AL, Blandford A. Don't forget your pill! Designing effective medication reminder apps that support users' daily routines. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. New York, NY: Association for Computing Machinery (2014). p. 2269–78. doi: 10.1145/2556288.2557079

58. Alqahtani F, Orji R. Insights from user reviews to improve mental health apps. *Health Informatics J.* (2020) 26:2042–66. doi: 10.1177/1460458219896492

59. Borghouts J, Eikey E, Mark G, Leon CD, Schueller SM, Schneider M, et al. Barriers to and facilitators of user engagement with digital mental health interventions: systematic review. *J Med Internet Res.* (2021) 23:e24387. doi: 10.2196/24387

60. Bevan Jones R, Stallard P, Agha SS, Rice S, Werner-Seidler A, Stasiak K, et al. Practitioner review: co-design of digital mental health technologies with children and young people. *J Child Psychol Psychiatry.* (2020) 61:928–40. doi: 10.1111/jcpp.13258

61. Olmert T, Cooper JD, Han SYS, Barton-Owen G, Farrag L, Bell E, et al. A combined digital and biomarker diagnostic aid for mood disorders (the delta trial): protocol for an observational study. *JMIR Res Protoc.* (2020) 9:e18453. doi: 10.2196/18453

62. Kessler RC, Ustün TB. The world mental health (WMH) survey initiative version of the world health organization (WHO) composite international diagnostic interview (CIDI). *Int J Methods Psychiatr Res.* (2004) 13:93–121. doi: 10.1002/mpr.168

63. Kessler RC, Akiskal HS, Angst J, Guyer M, Hirschfeld RMA, Merikangas KR, et al. Validity of the assessment of bipolar spectrum disorders in the WHO CIDI 3.0. *J Affect Disord.* (2006) 96:259–69. doi: 10.1016/j.jad.2006.08.018

64. FAQ. *Columbia University Department of Psychiatry*. (2018). Available online at: https://www.columbiapsychiatry.org/research/research-labs/diagnostic-and-assessment-lab/structured-clinical-interview-dsm-disorders-12 (accessed September 6, 2022).

65. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med.* (2001) 16:606–13. doi: 10.1046/j.1525-1497.2001.016009606.x

66. Goldberg LR. The structure of phenotypic personality traits. *Am Psychol.* (1993) 48:26–34. doi: 10.1037//0003-066x.48.1.26

67. World Health Organization. *The ICD-10 Classification of Mental and Behavioural Disorders*. 10th Revis ed. Geneva: World Health Organization (1993).

68. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. Washington, DC: American Psychiatric Publication (2013).

69. Altman EG, Hedeker D, Peterson JL, Davis JM. The altman self-rating mania scale. *Biol Psychiatry.* (1997) 42:948–55. doi: 10.1016/S0006-3223(96)00548-3

70. Angst J, Adolfsson R, Benazzi F, Gamma A, Hantouche E, Meyer TD, et al. The HCL-32: towards a self-assessment tool for hypomanic symptoms in outpatients. *J Affect Disord.* (2005) 88:217–33. doi: 10.1016/j.jad.2005.05.011

71. Depue RA, Slater JF, Wolfstetter-Kausch H, Klein D, Goplerud E, Farr D. A behavioral paradigm for identifying persons at risk for bipolar depressive disorder: a conceptual framework and five validation studies. *J Abnorm Psychol.* (1981) 90:381–437. doi: 10.1037//0021-843x.90.5.381

72. Eckblad M, Chapman LJ. Development and validation of a scale for hypomanic personality. *J Abnorm Psychol.* (1986) 95:214–22. doi: 10.1037//0021-843x.95.3.214

73. Ghaemi SN, Miller CJ, Berv DA, Klugman J, Rosenquist KJ, Pies RW. Sensitivity and specificity of a new bipolar spectrum diagnostic scale. *J Affect Disord.* (2005) 84:273–7. doi: 10.1016/S0165-0327(03)00196-4

74. Hirschfeld RMA. The mood disorder questionnaire: a simple, patient-rated screening instrument for bipolar disorder. *Prim Care Companion J Clin Psychiatry.* (2002) 4:9–11. doi: 10.4088/pcc.v04n0104

75. Leung CM, Yim CL, Yan CTY, Chan CC, Xiang Y-T, Mak ADP, et al. The bipolar II depression questionnaire: a self-report tool for detecting bipolar ii depression. *PLoS One.* (2016) 11:e0149752. doi: 10.1371/journal.pone.0149752

76. Sheehan DV, Lecrubier Y, Sheehan KH, Amorim P, Janavs J, Weiller E, et al. The Mini-International Neuropsychiatric Interview (M.I.N.I.): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *J Clin Psychiatry.* (1998) 59:22–33.

77. Spitzer RL, Williams JB, Gibbon M, First MB. The structured clinical interview for DSM-III-R (SCID). I: history, rationale, and description. *Arch Gen Psychiatry.* (1992) 49:624–9. doi: 10.1001/archpsyc.1992.01820080032005

78. Cooper JD, Han SYS, Tomasik J, Ozcan S, Rustogi N, van Beveren NJM, et al. Multimodel inference for biomarker development: an application to schizophrenia. *Transl Psychiatry.* (2019) 9:83. doi: 10.1038/s41398-019-0419-4

79. Tennant R, Hiller L, Fishwick R, Platt S, Joseph S, Weich S, et al. The Warwick-Edinburgh mental well-being scale (WEMWBS): development and UK validation. *Health Qual Life Outcomes.* (2007) 5:63. doi: 10.1186/1477-7525-5-63

80. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol.* (2006) 3:77–101. doi: 10.1191/1478088706qp063oa

81. Titov N, Dear BF, Nielssen O, Wootton B, Kayrouz R, Karin E, et al. User characteristics and outcomes from a national digital mental health service: an observational study of registrants of the Australian mindspot clinic. *Lancet Digital Health.* (2020) 2:e582–93. doi: 10.1016/S2589-7500(20)30224-7

82. Mirea D-M, Martin-Key N, Barton-Owen G, Olmert T, Cooper J, Yeon S, et al. Impact of a web-based psychiatric assessment on the mental health and well-being of individuals presenting with depressive symptoms: longitudinal observational study. *JMIR Ment Health.* (2021) 8:e23813. doi: 10.2196/23813

83. NIHR. *Briefing Notes for Researchers – Public Involvement in NHS, Health and Social Care Research. Briefing Notes for Researchers – Public Involvement in NHS, Health and Social Care Research*. London: NIHR (2021).

84. Price A, Albarqouni L, Kirkpatrick J, Clarke M, Liew SM, Roberts N, et al. Patient and public involvement in the design of clinical trials: an overview of systematic reviews. *J Eval Clin Pract.* (2018) 24:240–53. doi: 10.1111/jep.12805

85. Wicks P, Richards T, Denegri S, Godlee F. Patients' roles and rights in research. *BMJ.* (2018) 362:k3193. doi: 10.1136/bmj.k3193

86. Faulkner A, Thomas P. User-led research and evidence-based medicine. *Br J Psychiatry.* (2002) 180:1–3. doi: 10.1192/bjp.180.1.1

87. Springham N, Robert G. Experience based co-design reduces formal complaints on an acute mental health ward. *BMJ Qual Improv Rep.* (2015) 4:u209153.w3970. doi: 10.1136/bmjquality.u209153.w3970

88. Brett J, Staniszewska S, Mockford C, Herron-Marx S, Hughes J, Tysall C, et al. Mapping the impact of patient and public involvement on health and social care research: a systematic review. *Health Expect.* (2014) 17:637–50. doi: 10.1111/j.1369-7625.2012.00795.x

89. Rock PL, Roiser JP, Riedel WJ, Blackwell AD. Cognitive impairment in depression: a systematic review and meta-analysis. *Psychol Med.* (2014) 44:2029–40. doi: 10.1017/S0033291713002535

90. Robinson LJ, Nicol Ferrier I. Evolution of cognitive impairment in bipolar disorder: a systematic review of cross-sectional evidence. *Bipolar Disord.* (2006) 8:103–16. doi: 10.1111/j.1399-5618.2006.00277.x

91. Hatch A, Hoffman JE, Ross R, Docherty JP. Expert consensus survey on digital health tools for patients with serious mental illness: optimizing for user characteristics and user support. *JMIR Ment Health.* (2018) 5:e46. doi: 10.2196/mental.9777

92. Chan AHY, Honey MLL. User perceptions of mobile digital apps for mental health: acceptability and usability – an integrative review. *J Psychiatr Ment Health Nurs.* (2022) 29:147–68. doi: 10.1111/jpm.12744

93. Gazalle FK, Frey BN, Hallal PC, Andreazza AC, Cunha ÂBM, Santin A, et al. Mismatch between self-reported quality of life and functional assessment in acute mania: a matter of unawareness of illness? *J Affect Disord.* (2007) 103:247–52. doi: 10.1016/j.jad.2007.01.013

94. Peralta V, Cuesta MJ. Lack of insight in mood disorders. *J Affect Disord.* (1998) 49:55–8. doi: 10.1016/S0165-0327(97)00198-5

95. Funnell EL, Spadaro B, Martin-Key N, Metcalfe T, Bahn S. mHealth solutions for mental health screening and diagnosis: a review of app user perspectives using sentiment and thematic analysis. *Front Psychiatry.* (2022) 13:857304. doi: 10.3389/fpsyt.2022.857304

96. Baños RM, Herrero R, Vara MD. What is the current and future status of digital mental health interventions? *Span J Psychol.* (2022) 25:e5. doi: 10.1017/SJP.2022.2

97. Linardon J, Shatte A, Messer M, Firth J, Fuller-Tyszkiewicz M. E-mental health interventions for the treatment and prevention of eating disorders: an updated systematic review and meta-analysis. *J Consult Clin Psychol.* (2020) 88:994–1007. doi: 10.1037/ccp0000575

98. Pew Research Center. *Health Online 2013.* (2013). Available online at: https://www.pewresearch.org/internet/2013/01/15/health-online-2013/ (accessed August 01, 2022).

99. Bauer M, Glenn T, Monteith S, Bauer R, Whybrow PC, Geddes J. Ethical perspectives on recommending digital technology for patients with mental illness. *Int J Bipolar Disord.* (2017) 5:6. doi: 10.1186/s40345-017-0073-9

100. Kang Y, Wang H, Li X, Tao Y, Yang X, Deng W, et al. A brief web-based screening plus emotional-disorder health education was associated with improvement of mental health awareness and service-seeking attitudes among patients seeking nonpsychiatric clinical services in China. *Depress Anxiety.* (2021) 38:571–87. doi: 10.1002/da.23118

101. Kim E-H, Coumar A, Lober WB, Kim Y. Addressing mental health epidemic among university students via web-based, self-screening, and referral system: a preliminary study. *IEEE Trans Inf Technol Biomed.* (2011) 15:301–7. doi: 10.1109/TITB.2011.2107561

102. Johnson JA, Sanghvi P, Mehrotra S. Technology-based interventions to improve help-seeking for mental health concerns: a systematic review. *Indian J Psychol Med.* (2022) 44:332–40. doi: 10.1177/02537176211034578

103. Tsai C-H, You Y, Gui X, Kou Y, Carroll JM. Exploring and promoting diagnostic transparency and explainability in online symptom checkers. In: *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. New York, NY: Association for Computing Machinery (2021). p. 1–17. doi: 10.1145/3411764.3445101

104. Woodcock C, Mittelstadt B, Busbridge D, Blank G. The impact of explanations on layperson trust in artificial intelligence-driven symptom checker apps: experimental study. *J Med Internet Res.* (2021) 23:e29386. doi: 10.2196/29386

105. Rosenman SJ, Levings CT, Korten AE. Clinical utility and patient acceptance of the computerized composite international diagnostic interview. *PS.* (1997) 48:815–20. doi: 10.1176/ps.48.6.815

106. Word Health Organization. *Suicide Rates*. (2022). Available online at: https://www.who.int/data/gho/data/themes/mental-health/suicide-rates (accessed September 6, 2022).

107. Sagar-Ouriaghli I, Godfrey E, Bridge L, Meade L, Brown JSL. Improving mental health service utilization among men: a systematic review and synthesis of behavior change techniques within interventions targeting help-seeking. *Am J Mens Health.* (2019) 13:1557988319857009. doi: 10.1177/1557988319857009

108. Yousaf O, Grunfeld EA, Hunter MS. A systematic review of the factors associated with delays in medical and psychological help-seeking among men. *Health Psychol Rev.* (2015) 9:264–76. doi: 10.1080/17437199.2013.840954

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Healthcare professionals' perception and satisfaction with mental health tele-medicine during the COVID-19 outbreak: A real-world experience in telepsychiatry

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Background: The use of telemedicine is increasingly being implemented, showing numerous benefits over other methods. A good example of this is the use of telemedicine following the breakdown caused by the COVID-19 pandemic. Previous experiences with telemedicine (TM) have not been significantly explored in relation to the professionals' own perspectives.

Objective: Identify and explore the perceptions and interests of mental health professionals who have performed TM during the period of pandemia.

Methods: A questionnaire on mental health professionals' perceptions of and satisfaction of TM, the Font Roja Work Satisfaction Questionnaire, was adapted and used. Data collected included 112 Psychiatric Service professionals who conducted TM in March 2020, after the country had been under lockdown for 10 weeks. Over 12.000 medical consultations were carried out by the phone, showing an overwhelming response to this method.

Results: High levels of satisfaction were recorded amongst professionals. TM would function as a complement to the traditional system of face-to-face visits (n-112, f-109, 96.5%). Only 9.7% (f-11) believed that digital or virtual interventions would completely replace face-to-face visits. 60.8% did not consider this monotonous work. The older the health workers were, the more satisfied they felt during their follow-up telephone consultation. The greater the previous experience, the more satisfaction was shown. There were gender differences: female mental health workers reported a greater level of comfort.

Conclusion: TM can be implemented with less effort, but it requires time, methods, and resources to be managed. Satisfaction among professionals is

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high, especially among those with more clinical experience. Patient satisfaction must be contrasted against this.

KEYWORDS

tele-medicine, healthcare professional's perception, COVID-19, pandemic, telepsychiatry, e-health

Introduction

The COVID-19 pandemic is the most critical public health issue this society has faced in the last 50 years. By October 27, 2021, more than 244 million people have been infected worldwide (5006675 in Spain), with 4968445 deaths (1, 2). This eventful issue forced mental health services to quickly modify their usual procedures to face the new situation (3, 4). The National Health System in Spain is made up of a set of health services dependent on public authorities. It is free and universal: consultations, access to emergencies and medicines are free. For this reason, the majority of Spaniards turn to the public health system on a regular basis. The method usually used is face-to-face attendance. Telemedicine (TM) has become an essential tool to guarantee mental health in this new situation (4, 5). However, it must be carefully analyzed to be considered effective in the future because as experiences in this field are remain limited (6, 7), even though they have increased in recent years. Little is known about the subjective perception, satisfaction, and interest in TM of mental health professionals who have conducted it both in a the pre-pandemic context (8) and during the pandemic outbreak (4, 5). Knowing professionals' perspectives is valuable since they diagnose and treat diseases based on the resources, they have access to (9–11). Based on these facts, TM's use should be planned and implemented for future scenarios or clinical development for the post-COVID-19 stage.

There are increasingly more studies based on the assistance provided during the pandemic COVID-19 (12–14) however, this study highlights the point of view of the professionals who have performed these services. From this perspective, gender differences among mental health professionals still remain under-researched and under-reported, despite the fact that most of the task force in mental health are women (2).

This study describes how mental health professionals of the Psychiatry Department at the University of Salamanca Health Care Complex (USHCC) adapted and perceived TM after switching from the traditional face-to-face model to the new widely-available TM system on March 16 2020, after the lockdown that lasted 10 weeks (15). We also focus on socio-demographic and gender differences, factors that must be analized (16). This point of view is interesting because it helps to analyze the perceived self-efficacy of the workers, and the difficulties they encounter in their work, and contributes to improving the quality of the services provided.

Based on previous information, the main hypotheses are:

- Telemedicine acceptance and satisfaction will increase among professionals exposed to this modality (way of working).

- Professionals carried out tele-matic consultations (telemedicine) will be more willing to use it as part of their future practice.

- Professionals' perception of patients' satisfaction will be more significant in patients attended by more satisfied and experienced professionals.

- Age or gender differences exist in professional satisfaction when applying telemedicine.

Materials and methods

Data were obtained from a sample of mental health professionals of the Psychiatry Service (PS) of the USHCC, including 45 different medical services and more than 900 beds. The PS includes most Salamanca Mental Health Network resources, including part of the drug dependence care network, community outpatient services, inpatient units and community flats. It also includes psychiatric emergency services and on-call doctors at the University Hospital (UH), plus a transversal program for suicide prevention and attention for refractory mental disorders.

One hundred and twelve participants participated in the study, 75 of them provided TM services while confined. During the first 10 weeks of the COVID-19 outbreak, over 12,000 medical consultations were conducted by phone. A summary of the data collected can be found in Figure 1.

Each professional was able to participate in the study; however, those professionals who did not apply TM only answered 18 questions from the questionnaire.

An observational descriptive, cross-sectional study was carried out to understand TM's expectations and satisfaction by PS members during the COVID-19 pandemic confinement. The analysis was performed in a single phase using a questionnaire developed and carried out by the authors.

A questionnaire on mental health professionals' perceptions and satisfaction of TM, the Font Roja Work Satisfaction Questionnaire, was adapted and used. The authors designed an adapted questionnaire based on the literature's references, including 49 closed-ended questions. This questionnaire includes some questions, grouped into nine factors, which

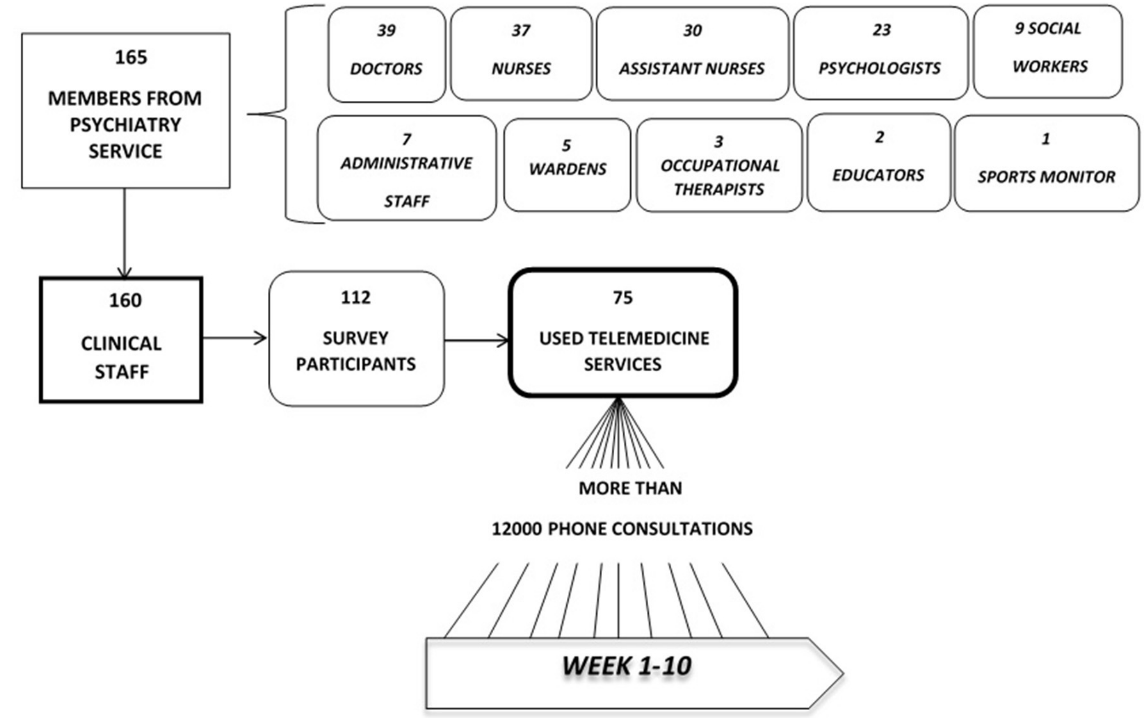

FIGURE 1
A summary of the data collection.

exploring different areas involved in job satisfaction: (1) work monotony; (2) job satisfaction; (3) stress/stress from work; (4) competition; (5) labor pressure; (6) promotional capacity; (7) relationship with superiors; (8) relationship with colleagues; (9) extrinsic characteristics of work (17). Four additional items were included: 2 to assess the work environment (18) and 2 to measure the professional's perception of the patient's satisfaction. The user satisfaction was measured on a scale of 1 (not at all satisfied) to 10 (maximum satisfaction). An additional open question was added at the end of the questionnaire to include qualitative information and personal feedback.

The online questionnaire was sent by email to all the staff members on May 15, 2020, and was available online until May 25, 2020. There were no exclusion criteria; every member from the PS received the e-mail. The procedures followed ethical standards and the Organic Law 3/2018, of the 5th of December, on the Personal Data Protection guaranteeing digital rights. The questionnaire was confidential, and subjects accepted by informed consent with the possibility to withdraw voluntarily at any time.

For quantitative data, normality tests were performed through either the Kolmogorov- Smirnov or Shapiro-Wilk Test. The described data was measured with the dispersion measures of mean and standard deviation for normal samples and the Median and Interquartile Range (IQR) for models that did not comply with the normality criteria.

Qualitative variables were explained with tables of good percentage or frequencies, which corresponded to be more appropriate. For parametric variables, an analysis was performed through either the Student's T-test for independent sample differences or the ANOVA test, when more than two groups existed. Mann-Whitney's U-test was used for non-parametric variables for two independent groups or Kruskal-Wallis when there were more than two separate groups. Qualitative variables were correlated by Fisher or Chi-Square tests, depending on which was appropriate in each case. The results were considered statistically significant for all analyses when the p-value was <0.05 (significance level $\alpha = 0.05$). SPSS software, v.26.0, was used for Mac.

Results

Sample description

The sample involved 112 participants, representing 70% of the PS total members ($n = 160$). 82.1% of the sample was working during COVID-19, and 66.4% carried out TM. In this sub-sample, as data to mention, 13 subjects (11.6%) lived with people who had COVID-19 while working remotely.

TABLE 1 Sociodemographic and professional profile among respondents.

	Total $n = 112\%$	**Women** $n = 85\%$	**Men** $n = 27\%$
Age			
<30	12 (10.7)	8 (10.1)	4 (16.0)
31-40	23 (20.5)	22 (27.8)	1 (4.0)
41-50	17 (15.7)	11 (13.9)	6 (24.0)
51-60	29 (25.9)	20 (25.3)	9 (36.0)
>60	23 (20.5)	18 (22.8)	5 (20.0)
Lost data	8 (7.1)	6 (7.05)	2 (7.4)
Professional category			
Doctors	36 (32.1)	24 (28.2)	12(44.4)
Psychology	24 (21.4)	17 (20.0)	7 (25.9)
Nursing	21 (18.8)	19 (22.4)	2 (7.4)
Social worker&	11 (9.8)	10 (11.8)	1 (3.7)
educators	10 (8.9)	9 (10.6)	1 (3.7)
Nursing assistant	3 (2.7)	2 (2.4)	1 (3.7)
Occupational therapist	7 (6.3)	4 (4.7)	3 (11.1)
Administrative staff			
Working experience (number of years)			
< 8	26 (31.8)	29 (34.5)	8 (29.6)
9-16	26 (25)	21 (25)	5 (18.5)
17-24	11 (11)	5 (6)	6 (22.2)
25-32	17 (17)	12 (14.3)	4 (14.8)
>33	21 (21)	17 (20.2)	4 (14.8)
Family situation during confinement			
Living alone	15 (13.4)	12 (14.3)	3 (11.5)
Reconciling family and	95 (84.8)	72 (85.7)	23 (88.5)
work-life	2 (1.8)	1 (1.2)	1 (3.7)
Lost data			

Furthermore, 84.69% of all those who carried out TM, had never done TM or did without previous training.

On another front, concerning other professionals' characteristics, it should be said that most of the subjects who performed telemedicine were Doctors (32.1%) and 20.5% of the sample had management responsibility. The professionals were homogeneously distributed by different age groups and years of experience; however, gender differences were not found in the distribution of the sample (Table 1).

Regarding the TM method used, there were no prior resources or data protection systems to facilitate videoconferencing be realized, so the telephone was the most popular. Medical consultation by phone is considered as an immediate and direct method of telematic assistance, which allows the user to contact the health professional from anywhere and in any circumstance. Most subjects tracked digital follow-up used this method, followed by chat/email (40%) and video calling (4/75, 9.3%). Most of health professionals who used these methods had direct access to the hospital health platforms, and could carry out the health service with computer support to consult and update the medical history of the patients.

It could be said the amount of TM accomplished was significant as 32 % of the sample made more than 40 connections per week.

Professional's subjective perceptions about telemedicine and the future

This new TM service was considered an innovative practice for most participants. Most full sample participants (85%) pointed out that TM would increase its use in the coming years and found it very useful. Meanwhile, 60% of the sample thought that TM was not yet well-defined and 4.4% of the sample felt that this option would not be implemented and did not consider it worthwhile. Despite the fact that only eight subjects (7.1%) stated that TM would not cause any side effects, most professionals thought TM would complement the traditional face-to-face visits model (97.3%). Furthermore, some gender differences were found (Table 2).

Job satisfaction perceived during COVID-19

More than half of the respondents (60.8%) did not consider this experience as monotonous work, and this result was significantly related to having prior knowledge of TM ($P = 0.02$).

Concerning professionals' feelings about this practice, in our study, a majority of participants (71.6%) perceived some responsibility when making decisions and 14.9% of the subjects felt very tired at the end of the day, while 50% reported the opposite feeling. Furthermore, 16.3% of the sample had mood disturbance, in comparison to half of the respondents that did not experience any mood alteration (50%) related to the change from face-to-face to TM. Secondly, while a small number of participants (6.8%) indicated an over-strain, 35.5% of participants indicated they could disconnect at the end of the day. In our study, the failure to disconnect at the end of the day has been related to the confinement situation (living alone vs. merging social and family life 90.4%) and a significant relationship between the two variables was found ($p = 0.041$).

Almost all subjects (83.2%) considered themselves independent to do their work, 75.6% were satisfied with their work, 50% felt their work was well-recognized and 68.9% perceived that they had had the opportunity to learn new aspects. The Work Satisfaction Questionnaire

TABLE 2 Professional's perceptions about TeleMedicine.

	Total $n = 112\%$	**Women** $n = 85\%$	**Men** $n = 27\%$
Time off work during confinement			
Yes	19 (17)	16 (19)	3 (11.1)
No	92 (82.1)	68 (81)	24 (82.9)
Lost data	1 (0.9)	1 (1.2)	0
Cohabitation with COVID-19 infected people during confinement			
Yes	13 (11.6)	10 (11.8)	3 (11.1)
No	96 (85.7)	72 (84.7)	24 (88.9)
Not applicable	3 (2.7)	3 (3.5)	0
Management responsibility			
Yes	23 (20.5)	14 (16.5)	9 (33.3)
No	89 (79.5)	71 (83.5)	18 (66.7)
Telemedicine previous experience			
Yes	50 (44.6)	35 (41.2)	15(55.6)
No	62 (55.4)	50 (58.8)	12(44.4)
Future perspectives about telemedicine implementation			
Increased use	96 (85.7)	74 (87.0)	22 (81.5)
Decreased use	5 (4.5)	2 (2.4)	3 (11.1)
No variation	11 (9.8)	9 (10.6)	2 (7.4)
Appropriate resources are available for Telemedicine			
1. Totally disagree	21 (18.8)	12 (14.1)	9 (34.6)
2. Partly disagree	39 (34.8)	29 (34.1)	10(38.5)
3. Neither agree nor disagree	45 (40.2)	39 (45.9)	6 (23.1)
4. Partly agree	4 (3.6)	4 (4.7)	0 (0)
5. Totally agree	2 (1.8)	1 (1.2)	1 (3.8)
Lost data	1 (0.9)	0	1 (3.7)
Telemedicine is regulated appropriately			
1. Totally disagree	24 (21.4)	15 (17.9)	9 (33.3)
2. Partly disagree	45 (40.2)	33 (39.3)	12(44.4)
4. Partly agree	37 (33.0)	32 (38.1)	5 (18.5)
5. Totally agree	5 (4.5)	4 (4.8)	1 (3.7)
Lost data	1 (0.9)	1 (1.2)	0
Telemedicine could have secondary effects			
1. Totally disagree	8 (7.1)	5 (6.0)	3 (11.1)
2. Partly disagree	28 (25.0)	25 (29.8)	3(11.1)
3. Neither agree nor disagree	46 (41.1)	34 (40.5)	12(44.4)
4. Partly agree	17 (15.2)	11 (13.1)	6 (22.2)
5. Totally agree	12 (10.7)	9 (10.7)	3 (11.1)
Lost data	1 (0.9)	1 (1.2)	0
Telemedicine could replace on-site visits			
Yes	11 (9.8)	7 (8.4)	4 (14.8)
No	99 (88.4)	76 (91.6)	23(85.2)
Lost data	2 (1.8)	2 (2.4)	0
Telemedicine could supplement on-site visits	109 (97.3)	82 (96.5)	0 (0)
Yes	3 (2.7)	3 (3.5)	27 (100)
No			0

TABLE 3 The satisfaction of the professionals performing telemedicine and differences according to gender.

Work satisfaction questionnaire of font roja

	Total [Mean (SD)]	Men (M)	Women (M)	*P*
"My work does not change. I find it monotonous".	2.24 (1.01)	2.21	2.25	.76
"I have been responsible for making decisions."	3.95 (0.91)	3.90	3.96	.71
"I have felt exhausted at the end of the working day."	3.42 (0.92)	3.50	3.39	.88
"I have not disconnected from work at the end of the working day."	3.12 (1.25)	3.02	3.40	.18
"I have had to do my best in my daily work."	**3.97 (0.92)**	**3.55**	**4.13**	**.03**
"My work has changed my mood."	2.39 (1.10)	2.45	2.37	.90
"I have been satisfied with my work."	**3.95 (0.95)**	**3.50**	**4.11**	**.04**
"I have been independent to organize my work."	4.12 (1.01)	3.95	4.19	.35
"I have had the chance to learn new things."	3.85 (1.14)	3.50	3.98	.24
"I am interested in the work I have carried out."	4.23 (0.95)	3.95	4.34	.12
"I have the feeling that the work I have carried out it is no worth."	1.46 (0.78)	1.60	1.41	.16
"I have obtained professional recognition for my work."	**3.39 (1.12)**	**2.65**	**3.67**	**.002**
"The relationship with my superior has been cordial during this period"	4.43 (0.98)	4.05	4.57	.19
"The relationship with my co-workers has been cordial during this period"	**4.53 (0.78)**	**4.20**	**4.65**	**.02**
"I have the proper salary concerning what I have been doing."	**3.14 (1.30)**	**2.05**	**3.54**	**.00**
"I think I occupy the position I deserve."	**3.92 (1.02)**	**3.40**	**4.11**	**.02**
"I think I have the opportunity to progress."	3.16 (1.11)	3.40	3.07	.19
"I have not had enough time to organize my work."	2.71 (1.12)	3.15	2.55	.056
"I knew what was expected from my work."	3.65 (0.97)	3.55	3.69	.52
"I think my work has been disproportionate."	**2.66 (0.96)**	**3.25**	**2.43**	**.006**
"My co-workers' problems have affected me."	3.16 (1.31)	3.05	3.20	.64
"I often feel I may not be able to carry out my work."	1.68 (0.76)	1.50	1.74	.16
"I have not had enough resources to do my work."	**3.07 (1.23)**	**3.70**	**2.83**	**.007**
"Competitiveness has been very stressful for me."	1.72 (0.94)	2.00	1.62	.23
"My work environment (at home) has prevented me from doing my job satisfactorily."	**2.11 (1.31)**	**2.85**	**1.83**	**.01**
"The physical structure of my work environment has interfered with my performance."	1.96 (1.15)	2.20	1.86	.43
"In general, assess your satisfaction with the telemedicine you have carried out."	7.41 (1.83)	6.70	7.68	.06
Patients' satisfaction concerning telemedicine perceived by professionals	7.93 (1.50)	7.60	8.06	.55
"In general, assess patients' satisfaction concerning the telemedicine carried out."				
"In general, assess the degree of comfort experimented by the patients concerning the telemedicine."	**7.76 (1.45)**	**6.85**	**8.09**	**.009**

M, Mean; SD, Standard deviation.

category "I have gained recognition for my work" also showed a statistically significant correlation depending on whether the subjects reconciled work and family life or lived alone ($P = 0.02$). Among all the participants, only one perceived that thet could not do their job (1.4%), while 85.1% felt qualified.

Under other matters, 47.3% considered having a salary suitable for the work done and 67.5% an acceptable position. Competitiveness did not appear to be a problem in these circumstances, as only three subjects reported stress or tension because of that fact. Some professionals (39.2%) perceived that they received enough time to organize their work, while 23% lacked time. More than half of the staff (62.1%) knew what was expected of them at work, while the 16.2% had some doubts about their task.

There is a relationship between the category: "how problems of other colleagues can affect you" and the situation of coexistence during the confinement (living alone vs. merging social and family life) $P = 0.008$. It should be noted that 30 subjects of the total sample ($n = 160$) were infected by COVID, although sick leaves did not appear to correlate with any other items (categories).

Relating the extrinsic characteristics of the work, the same number of subjects (36.5%) seemed to have the right resources to perform their work which is statistically related to a better adaptation of the work ($P < 0.001$), better working environment ($P = 0.002$) and the physical structure of work performed at home ($P = 0.02$). Most respondents (67.6%) did not consider that the work's physical structure at home interfered with their ability to carry it out.

Some gender differences were detected in satisfaction showing that females were more prone to TM and more satisfied and adapted (Table 3).

Telemedicine general satisfaction

Respondents scored a high perceived satisfaction with their work done with TM (Me = 8; IQR = 8 ($n = 73$) being the highest score 9/10 (very satisfied) (Figure 2).

Previous experience with TM seems to be related to more satisfaction in its performance ($P = 0.029$). There were no statistically significant differences between the different professional categories concerning perceived satisfaction when conducting TM. According to our results, satisfaction with telemedicine was also not related to professional responsibility. However, the group with more than 30 years of experience showed the highest satisfaction rates. Linear regression was generated to predict participants' satisfaction with their therapy performed according to their age. The older the health workers were, the more satisfied they felt with their telephone follow-up model. This model would have great goodness of fit index (R-squared-0.94), so it would be appropriate to predict one variable over the other. Moreover, TM's positive opinions for the future were significantly related to the respondents' general satisfaction ($P = 0.002$) and with more social connections, professionals had more satisfaction with the activity performed ($P = 0.007$).

Professional's perception of patient's satisfaction

The mental health care providers also positively assessed the degree of satisfaction and comfort perceived from the patients receiving TM (Me = 8, IQR = 7 ($n = 74$), indicating that patients were "quite satisfied" with the treatment received. It is remarkable that five participants point out the risk of dehumanization in open questions and that human contact is needed for a good therapeutic relationship. On the other hand, the perceived professional satisfaction of the patients' approval was related to age ($P = 0.01$), according to the previous linear regression model (Me = 8; IQR = 7; average score = 7.76 (DT = 1,451; $n = 74$). This subjective perception of the patient's comfort was also statistically related to the gender variable ($P = 0.009$).

Discussion

The main hypotheses of this study were confirmed: Telemedicine acceptance and satisfaction increased among professionals exposed to this modality (who participated in it's use); Most of the Professionals who carried out telemedicine stated that they had expectations about the increased use of telemedicine as part of their future practice; Professionals' perception of patients' satisfaction was related to experienced professionals. However, it was not more significant in patients attended by more satisfied professionals. There were age and gender differences in professional satisfaction when applying telemedicine.

The mental health professionals showed, in general, an excellent clinical experience with TM, even though they had little any previous experience with it. This new model was performed through multiple calls and was carried out unexpectedly with little resources or legal regulation and no adaptation or prior training. Professionals mostly managed to reconcile family and work-life despite the pandemic circumstances, and in general, they were quite satisfied with the TM they had performed. The work was done autonomously, adapting personal preferences and peculiarities to the new task and employment situation. Older age had a positive relationship over the satisfaction with the job done, and simultaneously, professionals perceived the approval and satisfaction from most of their patients. Therefore, the higher the clinical experience, the greater the satisfaction. This could be related to more increased safety and confidence in their prolonged professional activity.

Matching previous studies, TM's satisfaction and efficiency in professionals, including psychiatrists, is high (8). Some gender differences were detected, showing that females are more likely to carry out TM (19) and are more satisfied and adapted when conducting this modality. This fact has not been described previously, but it is a well-known that females are more likely to engage in different e-health behaviors than males (20).

Professionals felt that patients were satisfied, which overlaps previous studies addressing patients' perception of the use of TM (21). There is evidence of high patients satisfaction when receiving TM in other sanitary fields (22, 23).

In general, patients and providers/professionals are satisfied with telepsychiatry services, even though providers/professionals tend to express more concerns about the telepsychiatry's potentially adverse effects. The therapeutic relationship with TM is comparable to face-to-face services in terms of reliability of clinical evaluations and treatment outcomes (24), especially in the post-COVID era when the psychopathological presentation will be different (25).

This sample identifies TM as a new and widely generalized tool that will continue to grow in the future after adopting the methods, time, resources, professional stress, and some essential features like family reconciliation. This aspect became important

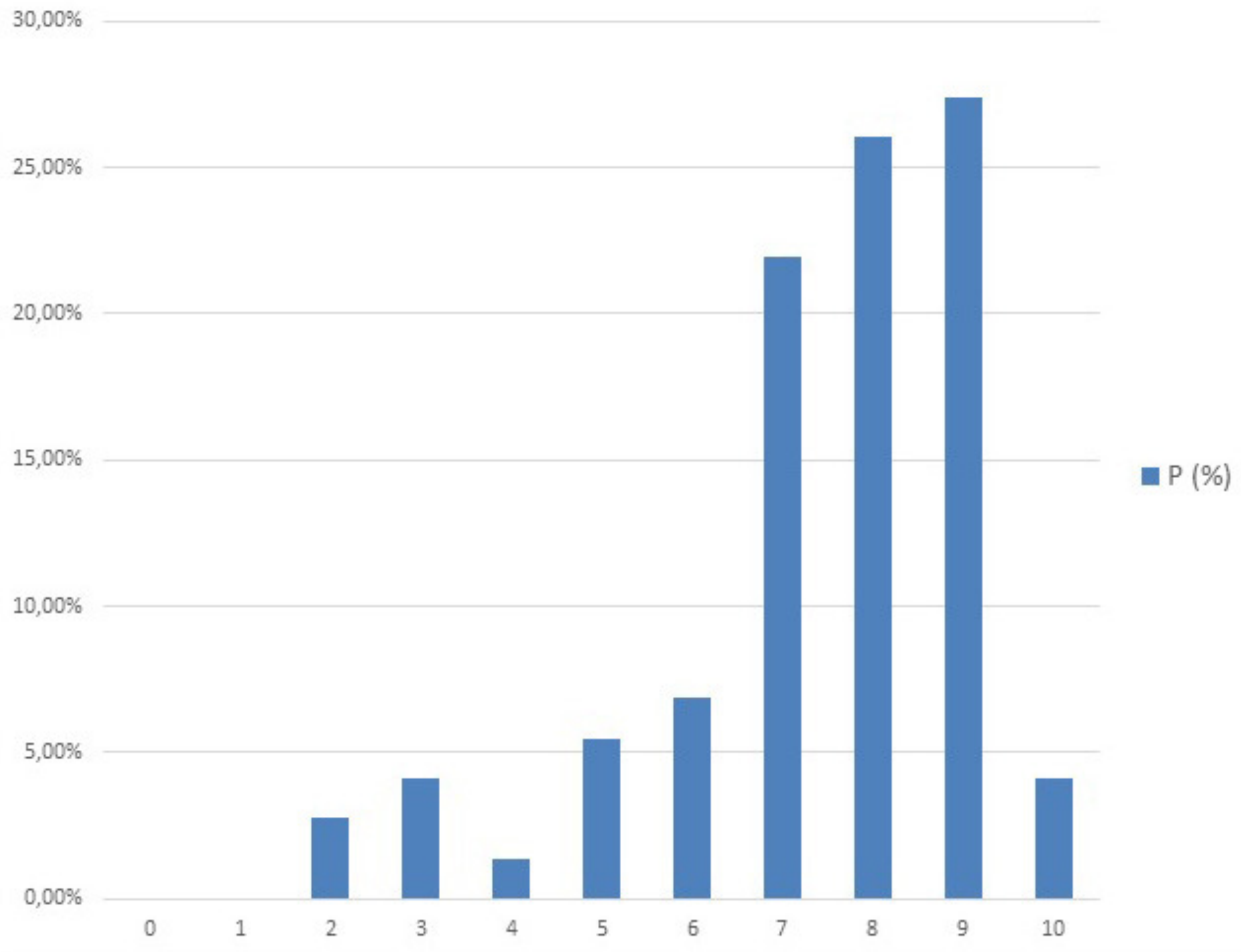

FIGURE 2
Level of general satisfaction on telemedicine (range 0–10).

when considering the high prevalence of anxiety and depression due to the COVID-19 pandemic (22).

There is some data on clinical interventions in severe mental disorders and TM, such as care of patients with schizophrenia (24–26) and on the benefits and costs when applying internet cognitive behavioral therapy (I-CBT) (27). Neither of our results is comparable to previous research describing phone calls for the training of functional skills (28); the use of mobile devices to decrease hospitalizations (29) to promote treatment adherence in outpatients in remission (25). These experiences can respond to link scientific evidence and clinical reality (28). Other pathologies have received care attention/treatment through TM, including patients with obsessive-compulsive disorder (29), mental health care for patients with intercultural difficulties (30), early detection and diagnosis in patients with Alzheimer's disease or mild cognitive impairment (31), and crisis interventions (32).

The use of telepsychiatry in the COVID-19 pandemic has been scarcely discussed (3, 5, 33, 34) with some experiences among psychologist, psychotherapists and clinicians. Professionals tend to prefer face-to-face care to telematics, although their experiences with telematic care during the COVID-19 pandemic were better than expected (35, 36).

This research helps the populations living far from the mental health clinics. We can agree with some of TM's advantages, such as better quality and access to care and related cost decreased. Moreover, according to the pharmaceutical companies' plans, an increase in TM's annual growth rate (between 13 and 27%, with valuation growing over 20 billion US dollars in the next several years) is expected (3). In this sense, combining TM with psychoeducation shows greater efficacy than the regular visits in the overall functioning of patients with bipolar disorder (37).

Nevertheless, our results emphasized that not all features are positive. TM shows some inconveniences and difficulties in the real world (38). Some participants (6.8%) perceived this new model as tiring at the end of the day. Most of the sample believed telemedicine could have side effects and suggested dehumanization risks in the assistance. Chakrabarti et al. (39) referred to perceived difficulties in different areas, such as communication or building a good relationship, and uncertainty over legal, regulatory, and ethical issues could influence somewhat negative attitudes regarding this model among physicians. A possible disadvantage could be that there were many failed phone calls (around 25%); additionally, some patients were either at work or accompanied by relatives when receiving the phone call, so their availability and intimacy could not be guaranteed.

Limitations

The use of the telephone restricts the observation of the patient's non-verbal and qualitative behavior. The gold standard of e-health services should be video-conference, but in the context of the pandemic, its use was marginal due to lack of resources. The use of the telephone was considered a previous step to digital tools despite of its limitations.

The stressful state may have influenced the professional opinions of the sample during the pandemic.

In this naturalistic study, the collected data's standard practice features would not differentiate the first consultations' weight vs. follow-ups. On the other hand, the results have been obtained after a short time of performing TM (2 months), and their evolution over time remains unknown.

The previous data acquired is not underpinned by clinical trials or pilot studies. Overall, previous works support the non-inferiority of remote psychiatric care in the evaluation and treatment compared to face-to-face care (40), not regarding the age, kind of population, or mental disorder. However, specific people (children and adolescents) do need some adjustments (41). However, we describe the difficulties of applying telemedicine in the real world.

The pandemic brought about a radical change in the way of treating patients. The priority after this has been to give normality and continuity to patients who were generally willing to return to face-to-face consultations, so no more data on satisfaction with telemedicine has been collected since that date. In the future, it would be interesting to assess whether patients and professionals would be interested in giving continuity to telematic services in a context of regular assistance. As well, the mental health of the professionals should be taken into account in order to evaluate the adaptation to the new technologies use (42, 43).

Conclusion

Telemedicine is a tool that has been identified as a complement in clinical practice and a world-class resource in pandemic situations such as COVID-19's. It can be deployed without difficulties, although these equate to procedures, time, methods, and resources. Satisfaction between professionals was high, especially those with more clinical experience and those with previous telemedicine practice. Gender and professional differences should be carefully studied. However, some disadvantages should be considered, and perhaps therapeutic relationships could become impaired. Patient satisfaction should be contrasted, and the planning and decision-making of when to use face-to-face vs. online techniques should be widely considered.

The feasibility of performing telemedicine consultations has been generalized with all types of patients, even with a shallow level of training and preparation in high-pressure situations (lockdown). This condition has been representative of many psychiatry services around the world. Therefore, training and access to resources that allow fair use of telemedicine should be promoted; thus, the barriers in patient care would be reduced (44, 45). On the other hand, professionals' perceptions must be taken into account because they are the ones who prescribe the treatments (9–11). Additionally, it should be noted that patients' and mental health providers' satisfaction is crucial for telemedicine success (46). Therefore, a comprehensive and long term evaluation for measuring professionals' satisfaction in delivering telemedicine is vital for the future (47).

Data availability statement

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

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 for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

CR, BB-V, and NC-E conceptualized, designed, and supervised the study. DR-G, BB, and LA collected the data, performed data processing, and statistical analysis. BB, DR-G, and SG-L wrote the manuscript. CR and BB-V supervised the project. AM, MG, and LA critically revised and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

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

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References

1. University JH. *COVID-19 Dashboard.* (2020). Available online at: https://coronavirus.jhu.edu/map.html (accessed October 27, 2020).

2. Roncero C, Garcia-Ullán L. de la Iglesia-Larrad J, Javier I, Martín C, Andrés P, et al. The response of the mental health network of the Salamanca area to the COVID-19 pandemic: the role of the telemedicine. *Psychiatry Res.* (2020) 291:113–252. doi: 10.1016/j.psychres.2020.113252

3. Corruble E. A viewpoint from Paris on the COVID-19 pandemic: a necessary turn to telepsychiatry. *J Clin Psychiatry.* (2020) 81. doi: 10.4088/JCP.20com13361

4. Mukherjee A, Bandopadhyay G, Chatterjee SS. COVID-19 pandemic: mental health and beyond - the Indian perspective. *Ir J Psychol Med.* (2020) 38:140–4. doi: 10.1017/ipm.2020.63

5. Olwill C, Mc Nally D, Douglas L. Psychiatrist experience of remote consultations by telephone in an outpatient psychiatric department during the COVID - 19 pandemic. *Ir J Psychol Med.* (2020) 38:132–9. doi: 10.1017/ipm.2020.51

6. Góngora AS, Fumero GV, Morón LN, Sainz BA. de la Torre ID, Franco M. Usability analysis of a system for cognitive rehabilitation, "gradior", in a spanish region. *Telemed J E Health.* (2020) 26:671–82. doi: 10.1089/tmj.2019.0084

7. De Las Cuevas C, Arredondo MT, Cabrera MF, Sulzenbacher H, Meise U. Randomized clinical trial of telepsychiatry through videoconference versus face-to-face conventional psychiatric treatment. *Telemed J E Health.* (2006) 12:341–50. doi: 10.1089/tmj.2006.12.341

8. Kachnic J, Wojtuszek M, Wutke J, Krysta K, Krystanek M. Telemedicine – how does it work in practice? *European Psychiatry.* (2017) 41:S147–8. doi: 10.1016/j.eurpsy.2017.01.1995

9. Roncero C, Szerman N, Terán A, Pino C, Vázquez JM, Velasco E, et al. Professionals' perception on the management of patients with dual disorders. *Patient Prefer Adherence.* (2016) 10:1855–68. doi: 10.2147/PPA.S108678

10. Roncero C, Vega P, Grau-López L, Martínez-Raga J, Barral C, Basurte-Villamor I, et al. Relevant differences in perception and knowledge of professionals in different spanish autonomous communities regarding availability of resources for patients with dual disorders. *Actas Esp Psiquiatry.* (2016) 44:1–12.

11. Roncero C, Vega P, Martínez-Raga J, Barral C, Basurte-Villamor I, Rodríguez-Cintas L, et al. Professionals' perceptions about healthcare resources for co-occuring disorders in Spain. *Int J Ment Health Syst.* (2014) 8:35. doi: 10.1186/1752-4458-8-35

12. Elhadi M, Elhadi A, Bouhuwaish A, Alshiteewi FB, Elmabrouk A, Alsuyihili A, et al. Telemedicine awareness, knowledge, attitude, and skills of health care workers in a low-resource country during the COVID-19 pandemic: cross-sectional study. *J Med Internet Res.* (2021) 23:e20812. doi: 10.2196/20812

13. Martínez Pérez DC, Agudelo García ÁM, Andrade Carrillo R, García Cano JF, Porras Cataño SM. Telepsiquiatría: una experiencia exitosa en Antioquia, Colombia. *Revista Colombiana de Psiquiatría.* (2020) 49:239–45. doi: 10.1016/j.rcp.2019.06.005

14. O'Brien M, McNicholas F. The use of telepsychiatry during COVID-19 and beyond. *Ir J Psychol Med.* (2020) 37:250–5. doi: 10.1017/ipm.2020.54

15. *European Union, Promoting Gender Equality in Research and Innovation.* (2020). Available online at: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/promoting-gender-equality-research-and-innovation (accessed March 31, 2021).

16. *Ministerio de Sanidad, C.y. BS. Situación COVID-19 en España.* (2020). Available online at https://cnecovid.isciii.es/covid19/ (accessed June 15, 2020).

17. Aranaz J. Cuestionario Font Roja. Un instrumento de medida de la satisfacción en el medio hospitalario. *Todo hospital.* (1988) 52:63–8.

18. Xiong J, Lipsitz O, Nasri F, Lui LM, Gill H, Phan L, et al. Impact of COVID-19 pandemic on mental health in the general population: A systematic review [published online ahead of print, 2020 August 8]. *J Affect Disord.* (2020) 277:55–64. doi: 10.1016/j.jad.2020.08.001

19. Luo J, Tong L, Crotty BH, Somai M, Taylor B, Osinski K, et al. Telemedicine Adoption during the COVID-19 pandemic: gaps and Inequalities. *Appl Clin Inform.* (2021) 12:836–44. doi: 10.1055/s-0041-1733848

20. Escoffery C. Gender Similarities and differences for e-health behaviors among U:S adults. *Telemed J E Health.* (2018) 24:335–43. doi: 10.1089/tmj.2017.0136

21. Buwalda V. EPA-1426 – Implementation of new systems as part of the clinical care processes: Knowledge of operations management and patients' attitude can make the difference. *European Psychiatry.* (2014) 29:1. doi: 10.1016/S0924-9338(14)78627-4

22. Lin CH, Tseng WP, Wu JL, Tay J, Cheng MT, Ong HN, Chen SY. A double triage and telemedicine protocol to optimize infection control in an emergency department in Taiwan during the COVID-19 pandemic: retrospective feasibility study. *J Med Int Res.* (2020) 22. doi: 10.2796/20586

23. Ohannessian R, Duong TA, Odone A. Global telemedicine implementation and integration within health systems to fight the COVID-19 pandemic: a call to action. *JMIR Public Health Surveill.* (2020) 6:e18810. doi: 10.2196/18810

24. Castro A, Larrain A, Fritsch E, Rojas G. Telepsiquiatría: una revisión sistemática cualitativa. *Rev Méd Chile.* (2012) 140:789–96. doi: 10.4067/S0034-98872012000600015

25. Depp CA, Mausbach B, Granholm E, Cardenas V, Ben-Zeev D, Patterson TL, et al. Mobile interventions for severe mental illness: design and preliminary data from three approaches. *J Nerv Ment Dis.* (2010) 198:715–21. doi: 10.1097/nmd.0b013e3181f49ea3

26. Firth J, Torous J. Smartphone apps for schizophrenia: a systematic review. *JMIR Mhealth Uhealth.* (2015) 3:e102. doi: 10.2196/mhealth.4930

27. Zhang MW, Ho RC. Moodle: the cost effective solution for internet cognitive behavioral therapy (I-CBT) interventions. *Technol Health Care.* (2017) 25:163–5. doi: 10.3233/THC-161261

28. Krzystanek M, Krzeszowski D, Jagoda K, Radzio B, Krysta K. Treatment of schizophrenia using tablet and smartphone based applications (Polish Study). *Eur Psychiatry.* (2016) 33:S27. doi: 10.1016/j.eurpsy.2016.01.845

29. Spaniel F, Vohlídka P, Hrdlicka J, KoŽený J, Novák T, Motlová L, et al. Itareps: information technology aided relapse prevention programme in schizophrenia. *Schizophr Res.* (2008) 98:312–7. doi: 10.1016/j.schres.2007.09.005

30. Mucic D. The use of a telemedicine model and its logistics to reach as many European refugees as possible. *Eur Psychiatry.* (2017) 41:S20. doi: 10.1016/j.eurpsy.2017.01.116

31. Costanzo M, Signorelli M, Aguglia E. EPA-0715 – Telemedicine and alzheimer: a systematic review. *Eur Psychiatry.* (2014) 29:1. doi: 10.1016/S0924-9338(14)78073-3

32. Swanson CL, Trestman RL. Rural assertive community treatment and telepsychiatry. *J Psychiatr Pract.* (2018) 24:269–73.

33. Rabinowitz T, Murphy KM, Amour J, Ricci MA, Caputo MP, Newhouse P. Benefits of a telepsychiatry consultation service for rural nursing home residents. *Telemed J E Health.* (2010) 16:34–40. doi: 10.1089/tmj.2009.0088

34. Tonn P, Reuter S, Kuchler I, Reinke B, Hinkelmann L, Stoeckigt S, et al. Development of a questionnaire to measure the attitudes of laypeople, physicians, and psychotherapists toward telemedicine in mental health. *JMIR Ment Health.* (2017) 4:e39. doi: 10.2196/mental.6802

35. Humer E, Stippl P, Pieh C, Pryss R, Probst T. Experiences of psychotherapists with remote psychotherapy during the COVID-19 pandemic: cross-sectional web-based survey study. *J Med Internet Res.* (2020) 22:e20246. doi: 10.2196/20246

36. Zentner K, Gaine G, Ethridge P, Surood S. Abba-Aji A. Clinicians' attitudes toward telepsychology in addiction and mental health services, and prediction of postpandemic telepsychology uptake: cross-sectional study. *JMIR Form Res.* (2022) 6:e35535. doi: 10.2196/35535

37. García-Alocén A, Bermudez-Ampudia C, Martínez-Cengotitabengoa M, et al. Telemedicine and bipolar disorder. *Eur Psychiatry.* (2016) 33:S121. doi: 10.1016/j.eurpsy.2016.01.148

38. Roncero C, Vicente-Hernández B, Casado-Espada NM, Aguilar L, Gamonal-Limcaoco S, Garzón MA, et al. The impact of COVID-19 pandemic on the Castile and Leon Addiction Treatment Network: a real-word experience. *Front Psychiatry.* (2020) 11:57555. doi: 10.3389/fpsyt.2020.575755

39. Chakrabarti S. Usefulness of telepsychiatry: a critical evaluation of videoconferencingbased approaches. *World J Psychiatry.* (2015) 5:286–304. doi: 10.5498/wjp.v5.i3.286

40. Drago A, Winding TN, Antypa N. Videoconferencing in psychiatry, a meta-analysis of assessment and treatment. *Eur Psychiatry.* (2016) 36:29–37. doi: 10.1016/j.eurpsy.2016.03.007

41. Llorca-Bofí V, Buil-Reiné E, Adrados-Pérez M, Del Agua E, Palacios-Garrán R. Psychotic depression in healthcare workers during the COVID-19 healthcare crisis: a case series. *Actas Esp Psiquiatr.* (2022) 50:163–6.

42. Andrés-Olivera P, García-Aparicio J, Lozano López MT, Benito Sánchez JA, Martín C, Maciá-Casas A, et al. Impact on sleep quality, mood, anxiety, and personal satisfaction of doctors assigned to COVID-19 units. *Int J Environ Res Public Health.* (2022) 19:2712. doi: 10.3390/ijerph19052712

43. Hilty DM, Shoemaker EZ, Myers K, Snowdy CE, Yellowlees PM, Yager J. Need for and steps toward a clinical guideline for the telemental healthcare of children and adolescents. *J Child Adolesc Psychopharmacol.* (2016) 26:283–9. doi: 10.1089/cap.2015.0129

44. Torous J, Jän KM, Rauseo-Ricupero N, Firth J. Digital mental health and COVID-19: using technology today to accelerate the curve on access and quality tomorrow. *JMIR Ment Health.* (2020) 7:e18848. doi: 10.2196/18848

45. Rodriguez-Villa E, Naslund J, Keshavan M, Patel V, Torous J. Making mental health more accessible in light of COVID-19: scalable digital health with digital navigators in low and middle-income countries. *Asian J Psychiatr.* (2020) 54:102433. doi: 10.1016/j.ajp.2020.102433

46. Kissi J, Dai B, Dogbe CSK, Banahene J, Ernest O. Predictive factors of physicians' satisfaction with telemedicine services acceptance. *Health Informatics J.* (2019) 26:1866–80. doi: 10.1177/1460458219892162

47. Law T, Cronin C, Schuller K, Jing X, Bolon DP. Conceptual framework to evaluate health care professionals' satisfaction in utilizing telemedicine. *J Am Osteopath Assoc.* (2019) 119:435–45. doi: 10.7556/jaoa.2019.080

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Negative social media-related experiences and lower general self-efficacy are associated with depressive symptoms in adolescents

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Social media are an integral part of adolescents' daily lives, and reviews have suggested an overall small association between more social media use and mental health problems. However, researchers have commonly investigated social media use in a time use perspective, rendering nuances in adolescents' social media experience less well explored. Thus, studies of relationships between social media use and mental health problems need also examine the nature of the events taking place on social media. This study aimed to examine depressive symptoms in adolescents in relationship to time spent on social media, negative social media-related experiences, and general self-efficacy. Data collected in a national survey, Ungdata 2021 ($n = 139{,}841$), was used. Multivariate linear regression analyses showed that time spent on social media was associated with depressive symptoms ($\beta = 0.09$, $p < 0.001$). However, negative social media-related experiences were more strongly associated with depressive symptoms (β ranging 0.09–0.22, all $p < 0.001$), and their inclusion weakened the initial association between time on social media and depressive symptoms. General self-efficacy was directly associated with lower symptom levels ($\beta = -0.29$, $p < 0.001$) but did not change the associations between social media use and depressive symptoms. The findings imply that not only time spent on social media, but in particular negative social media-related experiences, are related to depressive symptoms in Norwegian adolescents. General self-efficacy is an important resource for adolescents' mental health.

KEYWORDS

adolescents, depressive symptoms, general self-efficacy, nationwide study, social media

Introduction

Social media broadly refers to applications that allow users to engage in virtual interactions, with wider or narrower audiences (1). Social media have become a prominent aspect of 21st century culture, and they are widely adopted across the world (2, 3). Young people use social media more often than older people (4, 5), and certain types of image-based social media, such as Instagram and Snapchat, are more often preferred among people in the younger age groups (5). Most social media are financed through advertising that is algorithmically controlled, which means that each user gets content that is tailored to their special target group, and what the user has shown interest in in the past (6).

In Norway, 99% of young people between 13 and 18 years use social media, with YouTube, Snapchat, Instagram, Facebook, and TikTok being the most popular (7). Social media is an important arena for socialization among young people, and engaging with social media gives rise to positive as well as negative experiences (8). Compared to boys, girls appear to have more positive (e.g., communication, positive attention) and negative experiences (e.g., pressure, social comparison) on social media (8), and more negative experiences have also been found among adolescents with lower sociodemographic status (9). While longitudinal studies are still relatively few, studies of adolescents in Norway have found that more time spent on social media has predicted subsequent increases in alcohol use (10, 11) as well as increases in depressive symptoms and conduct problems (11). International studies have reported higher social media use to be associated with more conflict within the family (12) and lower satisfaction with family life (13). Together, the studies indicate a need for further research on the possible long-term consequences of social media use among adolescents, as well as on consequences for the families involved.

There is a need to expand the scope of inquiry beyond the mere time spent on social media to also include the nature of the interactions taking place on social media and the consequences they may have. While some have emphasized social media's positive potential for connection and inclusion (14–16), others have argued that social media are substitutes for real-life relationships and rather serve to increase stress, such as “fear of missing out” (17, 18). For adolescents, social media use may instigate a pressure toward having a large number of followers and receiving affirmation (“likes”) as indicators of social acceptance, and lack of affirmation has been found to result in negative emotions and higher levels of depressive symptoms (19). In a large cross-national study of adolescents aged 11–15 years from 42 countries throughout Europe (weighted $n = 180{,}919$), about 12% have experienced cyber-bullying on social media, and more time spent on social media has been related to a greater risk of being bullied (20). Social media may in the case of late night use cause sleep problems (21, 22), which is a risk factor for attention problems in school (23) and for developing depression (24). However, such specific consequences of social media use may go unnoticed in studies where time use is the sole measure of social media use. Thus, when specific negative social media-related events are not considered, the commonly detected associations between time spent on social media and poorer mental health may concern very different circumstances and obscure more relevant relationships (25, 26).

Researchers have found diverging results with regard to the relationships between social media use and aspects of mental health. Whereas several studies have shown associations between higher levels of social media use and poorer mental health (18, 22, 27–29), recent reviews have indicated mixed results and an overall weak negative association across studies (1, 30). The great variety of methods for measuring both social media use and mental health outcomes may partly account for the mixed results (31). Associations between social media use and mental health have also been found to vary by gender, with more social media use related to poorer mental health in females (32). Thus, to move research forward, future studies should carefully specify the population of interest and which aspect of social media use is of interest.

Among young people, psychological resource factors such as general self-efficacy have been associated with favorable mental health outcomes in several studies over the last decades (33–35). In addition, self-efficacy has been found to moderate associations between various aspects of social media use and mental health, indicating that associations between more social media use and poorer mental health may be stronger for people with low self-efficacy (36, 37). Thus, while self-efficacy in adolescents may be vulnerable to the influence from social media, self-efficacy may also be viewed as a psychological resource that can buffer against a potentially negative influence from social media on mental health. The aim of the study was to examine depressive symptoms in adolescents in relationship to social media use, negative social media-related experiences, and general self-efficacy.

Methods

Design and procedure

A comprehensive cross-sectional study, the Ungdata survey, is offered annually to municipalities throughout Norway. Usually, the survey is conducted every third year in each municipality (38). In 2021 the survey was completed by 139,841 Norwegian adolescents, aged 13–19 years, representing 209 out of 356 Norwegian municipalities. Ungdata has become an essential source of information on young peoples' health and wellbeing, both at the national and municipal levels (see www.ungdata.no). The survey is conducted by the Norwegian Social Research (NOVA) at Oslo Metropolitan University in a collaboration with the Regional Drug and Alcohol Competence Centers (KoRus). The surveys are financed partially by the Norwegian Directorate of Health and gauge different aspects of adolescents' lives, i.e., health issues, local environment, school issues, social media use, diet, alcohol consumption, relationships with friends and parents, leisure time activities and symptoms of depression.

Parents and students were informed *via* mail in advance, and parents of under-age adolescents (13–17 years of age) were assured that they could withdraw their children from participation at any time. If no prohibiting response was received from parents of under-age adolescents, the adolescents decided independently whether or not to participate in the survey. They decided in school whether they wanted to participate after being informed that participation was voluntary and that they could skip questions that they did not want to answer. The study was conducted as a web-based questionnaire administered at school during school hours with a teacher or an administrator present to answer questions. The students used approximately 30–45 min to complete the questionnaire.

Some parts of the questionnaire are used nationally in all participating municipalities, whereas other parts are selected or de-selected by each municipality. Therefore, the number of responses vary greatly between mandatory and elective parts of the questionnaire. In this study, most employed variables were derived from the mandatory questions used nationally, while some variables (general self-efficacy, reports on conflicts or arguments in the family due to social media use, and reports on not getting enough sleep due to social media use) were derived from elective parts of the survey. In addition, it was possible to complete only parts of the survey and leave the remaining questions unanswered. Thus, the number of responses on a specific question varied according to (i) whether the question was included in the survey presented to the individual participants (i.e., a decision made by the municipality), and (ii) whether the individual participant chose to respond to it.

Measures

Depressive symptoms

Depressive symptoms were measured using a six-item scale derived from the Depressive Mood Inventory (39), which was again based on the Hopkins Symptom Checklist (40). The adolescents were asked if during the past week they have been affected by any of the following: "Felt that everything is a struggle" (item 1), "had sleep problems" (item 2), "felt unhappy, sad or depressed" (item 3), "felt hopelessness about the future" (item 4), "felt stiff or tense" (item 5), "worried too much about things" (item 6). The six questions have four response categories: "Not been affected at all" (1), "not been affected much" (2), "been affected quite a lot" (3) and "been affected a great deal" (4). Sum scores were computed, ranging from 6 to 24; high scores indicated higher symptoms of depression. The depression scale has been psychometric evaluated among Norwegian adolescents. The scale showed good reliability (Person Separation Index: 0.802), and as a whole, the scale works reasonably well at a general level (41).

Sociodemographic factors

Gender (male/female), grade and centrality were used as covariates. Grade was used as an indicator for age, as age is not assessed within the survey. Centrality, as defined by Statistics Norway (42), was applied as a proxy for the grade of how centrally located a municipality in Norway is. Parents' level of education was measured by asking: "Did your parents go to university or to a university college?" Adolescents who were not in touch with one or both parents were asked to miss the question out. The response options were "No, none of them" (0) "Yes, one of them" (1), and "Yes, both of them" (2).

Social media use

Daily time spent on social media was measured by asking: "Think about what you do in a normal day, how much time do you spend on the following things: social media (Facebook, Instagram etc.)." Response options were no time, <30 min, 30 min—1 h, 1–2 h, 2–3 h and >3 h.

Negative social media-related experiences

Online bullying was assessed with the question "Have you been threatened or excluded on the internet?" with response options "yes, several times a week"; "yes, approximately once a week"; "yes, approximately once every 14 days"; "yes, approximately once a month"; "almost never" and "never." Participants were asked whether the use of social media had resulted in "conflicts or arguments in the family" or "not getting enough sleep," with response options "yes" and "no." Further, the adolescents were asked to indicate on a five-point scale (not at all–very much) whether they had experienced "pressure to have many followers and likes on social media." Responses on the scaled variables ("online bullying" and "pressure to have many followers and likes") were recoded into dichotomous variables prior to analysis, with "never experienced online bullying" and "no pressure to have many likes and followers" coded as "no" and all other responses coded as "yes."

Psychological resources

The *General Self-Efficacy Scale (GSE)* (43) is a questionnaire for assessing general self-efficacy among the general population aged 12 years and older. It has been translated into several languages (44), including Norwegian (45). The scale measures optimistic self-beliefs in coping with the demands of life. The short version of the GSE used in this study consists of 5 statements that respondents rate on a scale from 1 "completely disagree" to 4 "completely agree." Example statements are: "I always manage to solve difficult problems if I try hard enough" (item 1) and "If someone opposes me, I can find the means and ways to get what I want" (item 2). The score is calculated by summing the individual's scores on all items. The score range is 5–20, with higher scores indicating higher self-efficacy. High correlations with self-appraisal, self-acceptance, and optimism indicate theoretical accuracy of the self-efficacy concept (46), and psychometric analyses of the GSE has consistently produced one latent dimension and high measures of internal consistency between items (47–49). In the current study, Cronbach's α was 0.87.

Statistical analysis

Individuals who did not respond to specific items were removed casewise. The internal consistency of items in utilized scales were calculated by Cronbach's α. Descriptive analyses were performed for all employed measures. The dependent variable (depressive symptoms score) had a distribution which deviated from the normal distribution (Kolmogorov-Smirnov test $p < 0.001$), and it was skewed toward lower scores (skewness = 0.46, SE = 0.01) with the median value (Md = 12.0) being lower than the mean value (M = 12.9). However, skewed distributions frequently occur in large public health datasets without normally compromising the validity of parametric statistical testing (50). Therefore, we proceeded with parametric tests.

Depending on the number of groups to be compared, group differences in depressive symptoms were examined with independent t-tests or one-way ANOVA. In multiple comparisons, the Bonferroni correction was applied. Single (Model 0) and multiple linear regression analyses (Models 1–3) were used to assess associations between independent variables and depressive symptoms. In the multiple linear regression analyses, independent variables were entered in this sequence: Model (1) included daily time spent on social media and negative social media-related experiences (i.e., victim of online bullying; experienced conflicts or arguments in the family; experienced too little sleep due to social media use; and experienced pressure to have followers and likes on social media). Model (2) included the Model (1) variables while also including general self-efficacy. In Model 3, we included the Model (2) variables while adjusting for sociodemographic variables (age, gender, centrality, parents' education). Interaction analyses were performed to examine whether associations between negative social media-related experiences and depressive symptoms varied by gender and levels of general self-efficacy. In the event of statistically significant interactions, *post-hoc* analyses would repeat Model 3 separately for boys and girls and for participants with higher/lower general self-efficacy, respectively. Due to the large sample size, results with a corresponding $p < 0.01$ were considered statistically significant. The strength of associations (effect sizes) was interpreted in line with Cohen: β about 0.10 is small, about 0.30 is medium, and about 0.50 is large (51). Multicollinearity was checked with standard guidelines, stating that VIF should be below 5 and tolerance above 0.2 (52).

Ethics

The study was conducted in accordance with the Declaration of Helsinki. Before participating in the study, all students were asked to provide informed consent. The parents received oral and written information about the study and were given the opportunity to withdraw their children from participation. The information letter was approved by The Norwegian Center for Research Data (NSD). All data were collected anonymously and then analyzed by independent researchers who did not participate in the collection of the data. The study was approved by the Institutional Ethics Review Board at Inland Norway University of Applied Sciences (protocol code 21/01894).

Results

Sample characteristics

The characteristics of the sample are shown in Table 1. Participants in the survey were 139,841 pupils from lower secondary (13–15 years of age) and upper secondary schools (16–19 years of age). The response rate in lower secondary schools was 83% and in upper secondary schools 67%, yielding an average response rate of 75% (38). The age distribution in the sample was similar between most categories, yet with declining participation rates in the higher age groups. The proportions of boys and girls were similar. The largest groups of participants lived in places classified to be in the middle range on the centrality index. Among 47% of the sample, both parents had higher education.

Depressive symptoms, general self-efficacy, social media use and negative social media-related experiences

Information about depressive symptom levels, general self-efficacy, social media use, and negative social media-related experiences is shown in Table 2. The mean level of depressive symptoms was 12.9 (SD = 4.9), while the mean level of general self-efficacy was 14.7 (SD = 3.1). Thirty-three percent of the sample reported to use social media daily for more

TABLE 1 Sample characteristics.

Characteristics	*n* = 139,841
Age cohort	**n (%)**
8th grade secondary school	27,078 (19.4)
9th grade secondary school	26,667 (19.1)
10th grade secondary school	26,243 (18.8)
1st grade high school	23,021 (16.5)
2nd grade high school	19,396 (13.9)
3rd grade high school	13,054 (9.3)
Gender	**n (%)**
Boys	68,027 (48.6)
Girls	68,527 (49.0)
Centrality index	**n (%)**
1 (most central)	19,235 (13.8)
2	29,574 (21.1)
3	37,490 (26.8)
4	29,208 (20.9)
5	18,399 (13.2)
6 (least central)	5,840 (4.2)
Parents with higher education	**n (%)**
No parents with higher education	20,103 (14.4)
One parent with higher education	40,828 (29.2)
Both parents with higher education	66,309 (47.4)

Missing values represented 3.1% for age, 2.4% for gender, 0.1% for centrality, and 9.0% for parents with higher education.

TABLE 2 Depressive symptoms, psychological resources, social media use, and negative social media-related experiences in the sample.

Characteristics	*n*	Values
Depressive symptoms		**M (SD)**
Scale rating	126,445	12.9 (4.9)
Psychological resources		**M (SD)**
General self-efficacy	54,371	14.7 (3.1)
Daily time on social media	**n**	**%**
No time	3,359	2.4
<30 min	12,967	9.3
30 min—1 h	17,593	12.6
1–2 h	24,602	17.6
2–3 h	24,522	17.5
>3 h	46,166	33.0
Negative social media-related experiences		
Having been bullied on the internet	**n**	**%**
Yes	30,129	21.5
No	104,048	74.4
Arguments or conflict in the family	**n**	**%**
Yes	4,986	3.6
No	33,465	23.9
Not enough sleep		
Yes	19,063	13.6
No	19,450	13.9
Pressure to have followers and likes on SM		
Yes	43,062	30.8
No	84,971	66.4

SM is social media. On all mandatory parts of the questionnaire, missing values represented <10% of the possible responses: depressive symptoms 9.6%, daily time on social media 7.6%, bullied on the internet 4.1%, pressure to have followers and likes on social media 8.4%.

than 3 h. Twenty-two percent had experienced being bullied on the internet, while 30% had experienced pressure toward having followers and receiving likes on social media. There were fewer participants with valid responses to the questions about having experienced social media-related conflicts or arguments in the family, or not getting enough sleep due to social media use. Among those with valid responses on these questions, 13% reported to have experienced social media-related conflicts or arguments in the family, while 49.5% reported to have experienced not getting enough sleep due to social media use.

Depressive symptom levels in sample subgroups

The levels of depressive symptoms in sample subgroups are shown in Table 3. Depressive symptom levels were higher in the higher age groups, and girls had higher levels than boys. Depressive symptoms were also higher among adolescents living in urban districts, compared to rural, and higher among those whose parents did not have higher education. Those with higher levels (i.e., above median levels) of general self-efficacy had lower levels of depressive symptoms, compared to their counterparts. Those who spent more time on social media reported higher levels of depressive symptoms, compared to those who used social media less. For all types of negative social media-related experiences, the levels of depressive symptoms were significantly higher among those who had experienced the event, compared to their counterparts.

In the pairwise comparisons for variables with three or more categories (data not shown), differences in depressive symptom levels between age groups were statistically significant with one exception (10th grade vs. 1st grade high school).

TABLE 3 Depressive symptoms in sample subgroups.

Subgroups	Depressive symptoms		
Age cohort	**n**	**M (SD)**	**p**
8th grade secondary school	24,477	11.9 (4.8)	<0.001
9th grade secondary school	24,487	12.6 (4.9)	
10th grade secondary school	24,203	13.1 (4.9)	
1st grade high school	20,602	13.1 (4.8)	
2nd grade high school	17,240	13.4 (4.8)	
3rd grade high school	11,601	13.9 (4.7)	
Gender		**M (SD)**	**p**
Boys	60,270	11.2 (4.3)	<0.001
Girls	63,673	14.4 (4.8)	
Centrality index		**M (SD)**	**p**
1 (most central)	16,579	13.2 (4.9)	<0.001
2	26,801	13.0 (4.9)	
3	34,186	13.0 (4.9)	
4	26,582	12.7 (4.8)	
5	16,823	12.5 (4.8)	
6 (least central)	5,386	12.5 (4.9)	
Parents with higher education		**M (SD)**	**p**
No parents with higher education	18,286	13.4 (5.2)	<0.001
One parent with higher education	38,200	13.1 (4.9)	
Both parents with higher education	62,462	12.6 (4.7)	
Psychological resources		**M (SD)**	**p**
High GSE-5 (>Md)	18,009	11.0 (4.3)	<0.001
Low GSE-5 (≤Md)	35,263	13.8 (4.8)	
Daily time on social media		**M (SD)**	**p**
No time	3,114	11.3 (5.3)	<0.001
<30 min	12,325	11.2 (4.6)	
30 min−1 h	16,951	11.6 (4.4)	
1–2 h	23,807	12.2 (4.5)	
2–3 h	23,687	12.9 (4.6)	
>3 h	44,386	14.3 (5.0)	
Negative social media-related experiences			
Experienced online bullying		**M (SD)**	**p**
Yes	27,944	15.3 (4.9)	<0.001
No	97,955	12.2 (4.6)	
Arguments or conflict in the family		**M (SD)**	**p**
Yes	4,839	15.3 (4.9)	<0.001
No	32,604	12.5 (4.7)	
Not enough sleep		**M (SD)**	**p**
Yes	18576	14.2 (4.6)	<0.001
No	18,927	11.5 (4.6)	
Pressure to have followers and likes		**M (SD)**	**p**
Yes	41,730	15.1 (4.6)	<0.001
No	81,931	11.8 (4.6)	

GSE is General Self-Efficacy Scale.

Depressive symptom levels were also significantly different between levels of centrality, with two exceptions (between levels 2 and 3, and between levels 5 and 6). The highest levels of depressive symptoms were found among adolescents where none of the parents had higher education, whereas the lowest levels were found among adolescents where both parents had higher education. Higher levels of social media use were, for the most part, significantly related to higher levels of depressive symptoms, but depressive symptom levels were not significantly different between adolescents who did not use social media and those using social media for <1 h daily.

Social media use, negative social media-related experiences, and general self-efficacy associated with depressive symptoms

In preparation of the regression analyses, time spent on social media was re-categorized in order to obtain similar group sizes and a linear relationship with depressive symptoms (see Table 3). The two categories indicating the least daily time spent on social media were collapsed into one category (no social media use, up to 30 min daily). Otherwise, categories remained as before. No multicollinearity problems were detected (all VIFs ≤ 1.25, tolerance ≥ 0.80).

The results of the analysis of factors associated with depressive symptom levels are shown in Table 4. Crude associations with depressive symptoms were found for all included variables. More time spent daily on social media was associated with higher depressive symptom levels ($\beta = 0.23$, $p <$

TABLE 4 Linear regression analysis showing associations between daily time spent on social media, negative social media-related experiences, general self-efficacy, and depressive symptoms.

Independent variables	Model 0	Model 1 ($n = 36,961$)	Model 2 ($n = 26,865$)	Model 3 ($n = 24,474$)
Social media use	β	β	β	β
Daily time spent on social media	0.23	0.09	0.08	0.04
Explained variance (Adjusted R^2)		**5.2%**	**4.9%**	**4.9%**
Negative social media-related experiences				
Experienced online bullying	0.27	0.21	0.17	0.19
Arguments or conflict in the family	0.20	0.09	0.06	0.06
Not enough sleep	0.28	0.17	0.15	0.12
Pressure toward having followers and likes	0.32	0.22	0.19	0.13
Explained variance (Adjusted R^2)		**21.2%**	**20.4%**	**20.1%**
Psychological resources				
General self-efficacy	−0.38	-	−0.29	−0.26
Explained variance (Adjusted R^2)			**28.3%**	**27.7%**
Sociodemographic variables				
Higher age	0.11	-	-	0.11
Female gender	0.33	-	-	0.18
Centrality	−0.05	-	-	−0.03
Parents with higher education	−0.06	-	-	−0.03
Explained variance (Adjusted R^2)				**31.8%**

Dependent variable is depressive symptom level. Higher values on "centrality" indicates more rural. Table content is standardized β values. All values of β and R^2 are statistically significant at $p < 0.001$. Model 0 is single regression coefficients without any adjustment (crude associations). In Model 1, time on social media and social media-related experiences are entered in two separate blocks. Model 2 is Model 1 with the addition of general self-efficacy. Model 3 is Model 2 adjusted by sociodemographic variables. Bold is used to separate explained variance from beta values.

0.001), as was experience with any of the negative social media-related events (β ranging between 0.20 and 0.32, all $p < 0.001$). Higher levels of general self-efficacy were associated with lower levels of depressive symptoms ($\beta = -0.38$, $p < 0.001$).

As shown for the multivariate Model 1, more time spent on social media was associated with higher depressive symptom levels, but the association was weaker compared with the crude association ($\beta = 0.09$, $p < 0.001$). Having experienced any of the negative social media-related events was associated with higher depressive symptom levels, with associations being of varying strength (β ranging between 0.09 and 0.22, all $p < 0.001$). Variation in the negative social media-related events accounted for a larger proportion of the outcome variance (16.0%), compared to the variation in time spent on social media (5.2%).

When included in Model 2, higher self-efficacy was related to lower levels of depressive symptoms ($\beta = -0.29$, $p < 0.001$), explaining and additional 7.9% of the variance in depressive symptoms. The inclusion of general self-efficacy did not substantially change the associations between social media use, negative social media-related experiences, and depressive symptoms.

After adjusting by sociodemographic variables in Model 3, time spent daily on social media and having experienced any of the negative social media-related events were still associated with higher depressive symptom levels, and higher general self-efficacy was still related to lower depressive symptom levels. Higher age, female gender, living in more central areas, and having parents who did not have higher education were associated with higher depressive symptom levels.

Interaction analyses

Interaction analyses were performed to examine whether associations between negative social media experiences and depressive symptoms were moderated by gender and levels of general self-efficacy, respectively. Interactions were added in two subsequent iterations of the Model 3 regression analysis. In the first iteration, interaction terms gender × negative social media-related experiences (i.e., four separate interaction terms) were added to the Model 3 predictors, and in the second we added the interaction terms general self-efficacy × negative social media-related experiences. Gender significantly interacted

TABLE 5 Linear regression analysis showing associations between daily time spent on social media, negative social media-related experiences, general self-efficacy, and depressive symptoms by gender.

Independent variables	Boys (n = 11,574)	Girls (n = 12,900)
Social media use	β	β
Daily time spent on social media	0.02	0.05***
Explained variance (Adjusted R^2)	**1.3%*****	**2.6%*****
Negative social media-related experiences		
Experienced online bullying	0.22***	0.19***
Arguments or conflict in the family	0.02	0.09***
Not enough sleep	0.15***	0.11***
Pressure toward having followers and likes	0.13***	0.13***
Explained variance (Adjusted R^2)	**14.4%*****	**15.0%*****
Psychological resources		
General self-efficacy	−0.22***	−0.32***
Explained variance (Adjusted R^2)	**18.7%*****	**24.5%*****
Sociodemographic variables		
Higher age	0.12***	0.12***
Centrality	−0.04***	−0.02**
Parents with higher education	−0.03**	−0.03***
Explained variance (Adjusted R^2)	**20.5%*****	**26.1%*****

Dependent variable is depressive symptom level. Higher values on "centrality" indicates more rural. Table content is standardized β values. The models show direct associations when all variables are included. $^{***}p < 0.001$, $^{**}p < 0.01$. Bold is used to separate explained variance from beta values.

with "arguments or conflict in the family" ($p < 0.001$), whereas the remaining three interaction terms yielded non-significant results. General self-efficacy interacted with "arguments or conflict in the family" and "pressure toward having followers and likes" (both $p < 0.001$), whereas the two remaining interaction terms were non-significant. Based on these results, we repeated the Model 3 regression analysis separately for boys and girls, and for participants with higher and lower general self-efficacy scores (spilt by the median score).

The results for boys and girls are displayed in Table 5. The pattern of associations was mostly identical for the two genders. However, having experienced conflicts or arguments related to social media use was associated with a higher level of depressive symptoms among girls, but not among boys. Also, for girls the model accounted for a somewhat larger proportion of the variance in depressive symptoms, and the association between higher general self-efficacy and lower levels of depressive symptoms was stronger than for boys.

TABLE 6 Linear regression analysis showing associations between daily time on social media, social media-related experiences, and depressive symptoms by general self-efficacy levels.

Independent variables	Low self-efficacy (n = 15,892)	High self-efficacy (n = 8,582)
Social media use	β	β
Daily time spent on social media	0.04	0.04
Explained variance (Adjusted R^2)	**4.2%**	**3.9%**
Social media-related experiences	β	β
Experienced online bullying	0.22	0.20
Arguments or conflict in the family	0.08	0.08
Not enough sleep	0.12	0.16
Pressure toward having followers and likes	0.13	0.15
Explained variance (Adjusted R^2)	**17.0%**	**18.2%**
Sociodemographic variables	β	β
Higher age	0.10	0.11
Female gender	0.23	0.16
Centrality	−0.03	−0.04
Parents with higher education	−0.03	−0.04
Explained variance (Adjusted R^2)	**22.7%**	**21.9%**

Dependent variable is depressive symptom level. Higher values on "centrality" indicates more rural. Table content is standardized beta values. The models show direct associations when all variables are included. All values of β and R^2 are statistically significant at $p < 0.001$. Bold is used to separate explained variance from beta values.

The results for higher and lower levels of general self-efficacy are displayed in Table 6. The pattern of associations was practically identical for the two groups, and the models accounted for similar proportions of the outcome variance. The association between female gender and depressive symptoms was slightly stronger for adolescents with lower levels of general self-efficacy, compared to those with higher levels.

Differences between the initial and the final sample

Given the loss of participants in the multivariate analysis, we compared the sample included in the Model 3 regression analysis with the initial sample. In comparison to the initial sample, the restricted sample included in the Model 3 analysis had a lower level of depressive symptoms (M = 12.8 vs. M

= 12.9, Cohen's $d = 0.02$, $p < 0.001$) but a higher level of social media use (M = 4.6 vs. M = 4.5, Cohen's $d = 0.09$, $p < 0.001$). The restricted sample also had a higher proportion of participants in senior high school (54.3 vs. 37.8%), a higher proportion of girls (53 vs. 50%), a higher proportion had both parents without higher education (17.0 vs. 15.5%), and a higher proportion living in the less central areas of the country (44.3 vs. 36.9%, all $p < 0.001$).

Discussion

Main summary of results

This study found that negative social media-related experiences were associated with higher levels of depressive symptoms among Norwegian adolescents. When including negative social media-related experiences as independent variables together with daily time spent on social media, the association between time spent on social media and depressive symptoms was weakened, suggesting that negative social media-related events were responsible for some (but not all) of the association between time spent using social media and higher levels of depressive symptoms. Higher general self-efficacy levels were associated with lower levels of depressive symptoms.

Factors associated with depressive symptoms

In this study, more time spent on social media use was associated with higher levels of depressive symptoms. This corresponds with results from previous reviews that have suggested social media use to be associated with higher levels of depressive symptoms in adolescence (53). However, using a wider lens, a recent review and meta-analysis reported that associations between more social media use and poorer mental health varied considerably, with effect sizes ranging between 0.02 (*ns*) and 0.17 (54). In view of the variable results between studies and the small effect sizes often obtained, other factors may influence the relationship between social media use and depressive symptoms in adolescents (55).

In this study, we found that the inclusion of negative social media-related experiences in the regression model weakened the initial association between social media use and depressive symptoms, hence possibly accounting for some of the covariation between social media use and depressive symptoms. Among the included negative experiences, having experienced online bullying was shown to be most strongly associated with depressive symptoms. A relationship between having experienced online bullying and higher levels of depressive symptoms is consistent with findings from previous studies (56). These results support the idea that the content of social media use–what people experience during, and as a consequence of, social media use–is important to consider in relation to mental health outcomes, and that time spent on social media is merely one aspect of the social media exposure. While the results indicate that negative experiences related to social media use are relevant to consider, they also support the notion that there remains an independent relationship between time spent on social media and depressive symptoms in adolescents. This remaining relationship may be bi-directional or reversed, as recently suggested (57).

Almost half of the participants who responded to the questions related to sleep and social media use, reported not getting enough sleep due to social media use. This is in accordance with a recent Norwegian research report, stating that 50% of adolescents go to bed later than they should due to social media use (8). Previous studies have also suggested that social media use may cause sleep problems (21, 22), and our study substantiated higher depressive symptom levels among adolescents who have experienced sleep problems due to social media use. In addition, the results from our study showed that other problematic social media related experiences, such as "conflicts or arguments in the family" and "pressure to have many followers and likes," were associated with higher depressive symptom levels. We should note that family conflicts related to social media hinges not only on the adolescent's social media use, but also on parents' attitudes and behaviors toward their adolescent's use of social media. Studies have shown that over the past decades parents have become increasingly aware of, and involved with, their children's social media use (58, 59), which in turn may lead to more family conflict centered around the issue (12). In combination, the findings suggest that substantial proportions of adolescents experience problematic consequences of their social media use, and that having such experiences are related to higher depressive symptoms. However, the nature of the relationship is uncertain, and bi-directional relationships are viable (57).

Moreover, the frequency of experiencing negative social media-related events may differ between groups. For example, adolescents from less affluent backgrounds have been found to report negative experiences from social media use more often than those from more affluent backgrounds (9), and possibly, associations between social media-related experiences and depressive symptoms may differ between groups with higher or lower vulnerability. Supporting this view, a recent study concluded that getting fewer likes on social media was a greater risk factor for negative affect and thoughts and feeling rejected among adolescents who were already victims of school bullying, compared to those who were not (19).

While this study has focused on depressive symptoms as the potential outcome of social media use and -encounters, social media may also have a beneficial effect on adolescent wellbeing. Social media may ease the access to supports and allow for a diversity of interactions and friendships (53), and for some, the virtual interaction may be easier than face-to-face social interaction (14–16). In a Norwegian qualitative study adolescents revealed that social media contributes to amplify social relations, as it is much easier to communicate and keep in touch *via* social media than in real life (60). However, negative experiences on social media have been found to be more potent than positive experiences, as negative experiences have been significantly associated with higher levels of depressive symptoms, while positive experiences have been associated with minor and not statistically significant decreases in depressive symptoms (61). Individuals with depressive symptoms may also be more inclined to engage in social media for various reasons (57) and they may experience more negative interactions while doing so (61).

In this study, higher general self-efficacy levels were significantly associated with lower levels of depressive symptoms. Similarly, a previous study also showed that self-efficacy was related to depressive symptom levels, both concurrently and prospectively, but the nature of the associations varied by self-efficacy domain (62): a strong sense of efficacy for regulating negative affect was related to lower depressive symptoms, while stronger empathic self-efficacy was related to higher depressive symptom levels. In addition, a more recent study examining a cross-lagged model of associations found that depressive symptom levels predicted academic and emotional self-efficacy 6 months later, whereas self-efficacy did not predict subsequent depressive symptoms (63). Thus, the issue of causality in the relationship between self-efficacy and depressive symptoms is debated, and cyclical relationships are also viable. Previous studies have found that self-efficacy moderated associations between social media use and mental health (36, 37). Similarly, our study showed that general self-efficacy significantly moderated two of the associations between negative social media-related experiences and depressive symptoms. However, associations were only marginally different between adolescents with higher and lower levels of self-efficacy. In addition, including general self-efficacy in the regression model (Model 3) did not substantially change the associations between social media use, negative social media-related experiences, and depressive symptoms. Thus, despite significant interaction effects, the comparison of effect sizes in our study supports the view that associations between social media use and negative social media-related experiences and depressive symptoms do not differ substantially between adolescents with different levels of self-efficacy.

Comparisons with other studies are, to some extent, hampered by different questions and conceptualizations used across studies. For example, 22 % of the adolescents in this study reported to have experienced online bullying. This proportion is higher compared to the results of Craig et al. (20), where 12% reported having experienced cyberbullying on social media. However, these results are not fully comparable, given that more adolescents would logically report having experienced online bullying (as we asked in this study), compared to those having experienced cyberbullying on social media (as asked by Craig and co-workers). Online bullying, the concept used in our study, would logically encompass bullying within a wider internet-based context, including e.g., online gaming, and is not necessarily restricted to the social media context. For these reasons, our results should be interpreted with caution.

Study strengths and limitations

A considerable strength of the present study is the high participation rate, the large sample size, and the use of recently collected data (2021) which provide updated descriptions of adolescents' perceptions of life in Norway. The very large sample, and the resulting high statistical power, give rise to challenges in the interpretation of associations, where statistically significant results must be scrutinized with an emphasis on effect size. In this study, for example, we found several statistically significant interaction effects, yet close to negligible group differences when comparing categories of the moderator variables.

Another limitation is that the sample used for the Model 3 regression analysis was different from the initial sample with regards to the participants' level of depressive symptoms, time spent on social media use, age, gender, centrality, and their parents' educational level. Thus, our results concerned with factors associated with depressive symptoms are not fully representative of the general population of adolescents, in particular with regards to the age distribution.

A limitation of this study is the cross-sectional design, which precludes inferences about causal relationships. Depressive symptoms may not only be a result of social media use and exposure; such symptoms may also increase social media use and potentially the risk of experiencing adverse events, such as online bullying. In addition, the study relies on self-report measures, some of which with unknown psychometric properties, which may have led to unidentified misclassifications or measurement errors. While the questions used to assess negative social media-related experiences have been used in the Ungdata surveys for several years (64), we have no information about the validity of the questions. Furthermore, the associations found between social media use and depressive symptoms might be influenced by other factors that were not controlled for in the study.

Conclusion and implications for future research

This study showed that negative social media-related events were associated with higher levels of depressive symptoms among adolescents in Norway, and negative social media-related events appeared to account for some of the association between time spent using social media and higher levels of depressive symptoms. Higher general self-efficacy levels were associated with lower levels of depressive symptoms. More knowledge is needed about what types of events might constitute both positive and negative events related to social media use, and what outcomes they might produce. In particular, further research on cyberbullying and its contexts, is needed. Such research may include a larger diversity of online platforms where people interact with each other, including both social network platforms and online gaming platforms. Future research may also focus on identifying potential moderating variables, to enable a more comprehensive understanding of how social media use and -exposure may be differently associated with mental health outcomes in various groups of adolescents.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The data and materials from the Ungdata Surveys are stored in a national database administered by NOVA. The data are available for research purposes upon application. Further information about the study and the questionnaires can be found on the web page https://www.nsd.no/nsddata/serier/ungdata_eng.html. Requests to access these datasets should be directed to ungdata@oslomet.no.

Ethics statement

The studies involving human participants were reviewed and approved by Institutional Ethics Review Board, Inland Norway University of Applied Sciences. 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

TB analyzed the data and drafted the manuscript. AS, TS, AK, LL, and ML provided input to the analysis and presentation and edited the manuscript. All authors agreed to be responsible for the final submitted version of the manuscript.

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Conflict of interest

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

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References

1. Meier A, Reinecke L. Computer-mediated communication, social media, and mental health: a conceptual and empirical meta-review. *Comm Res.* (2021) 48:1182–209. doi: 10.1177/0093650220958224

2. Boulianne S. Social media use and participation: a meta-analysis of current research. *Inform Comm Soc.* (2015) 18:524–38. doi: 10.1080/1369118X.2015.1008542

3. Hunt YM, Beckjord EB, Moser RP, Hesse BW. Social media use in the United States: implications for health communication. *JMIR.* (2009) 11:e48. doi: 10.2196/jmir.1249

4. Feng G, Zhang Y, Lin Z. A meta-analysis of the effects of sociodemographic factors on social media adoption. *Int J Comm.* (2019) 13. Available online at: https://ijoc.org/index.php/ijoc/article/view/10088

5. Auxier B, Anderson M. *Social Media Use in 2021*. Pew Research Center. (2021). Available online at: https://www.pewresearch.org/internet/2021/04/07/social-media-use-in-2021/ (accessed October 1, 2022).

6. Carr CT, Hayes RA. Social media: defining, developing, and divining. *Atlant J Comm.* (2015) 23:46–65. doi: 10.1080/15456870.2015.972282

7. The Norwegian Media Authority. *Children and Media 2020*. [In Norwegian: Barn og medier 2020]. Oslo: Medietilsynet. (2020). Available online at: https://www.medietilsynet.no/globalassets/publikasjoner/barn-og-medier-undersokelser/2020/201015-barn-og-medier-2020-hovedrapport-med-engelsk-summary.pdf (accessed October 1, 2022).

8. Hjetland GJ, Finserås TR, Skogen JC. Worldwide in a keystroke - Adolescents' use and experiences with social media and online gaming [Norwegian: Hele verden er et tastetrykk unna. *Ungdommers Bruk og Opplevelser Med Sosiale Medier og Online Gaming] Oslo: Norwegian Institute of Public Health*. (2022). Available online at: https://www.fhi.no/publ/2022/hele-verden-er-et-tastetrykk-unna---ungdommers-bruk-og-opplevelser-med-sosi/

9. Skogen JC, Bøe T, Finserås TR, Sivertsen B, Hella RT, Hjetland GJ. Lower subjective socioeconomic status is associated with increased risk of reporting negative experiences on social media. Findings from the "LifeOnSoMe"-study. *Front Public Health.* (2022) 10. doi: 10.3389/fpubh.2022.873463

10. Brunborg GS, Skogen JC, Burdzovic Andreas J. Time spent on social media and alcohol use among adolescents: a longitudinal study. *Addict Behav.* (2022) 130:107294. doi: 10.1016/j.addbeh.2022.107294

11. Brunborg GS, Burdzovic Andreas J. Increase in time spent on social media is associated with modest increase in depression, conduct problems, and episodic heavy drinking. *J Adolesc.* (2019) 74:201–9. doi: 10.1016/j.adolescence.2019.06.013

12. Vannucci A, McCauley Ohannessian C. Social media use subgroups differentially predict psychosocial well-being during early adolescence. *J Youth Adolesc.* (2019) 48:1469–93. doi: 10.1007/s10964-019-01060-9

13. Savci M, Akat M, Ercengiz M, Griffiths MD, Aysan F. Problematic social media use and social connectedness in adolescence: the mediating and moderating role of family life satisfaction. *Int J Mental Health Addict.* (2022) 20:2086–102. doi: 10.1007/s11469-020-00410-0

14. Morahan-Martin J, Schumacher P. Loneliness and social uses of the Internet. *Comput Hum Behav.* (2003) 19:659–71. doi: 10.1016/S0747-5632(03)00040-2

15. Nowland R, Necka EA, Cacioppo JT. Loneliness and social internet use: pathways to reconnection in a digital world? *Perspect Psychol Sci.* (2018) 13:70–87. doi: 10.1177/1745691617713052

16. Thomas L, Orme E, Kerrigan F. Student loneliness: the role of social media through life transitions. *Comput Educ.* (2020) 146:103754. doi: 10.1016/j.compedu.2019.103754

17. Fumagalli E, Dolmatzian MB, Shrum LJ. Centennials, FOMO, and loneliness: an investigation of the impact of social networking and messaging/VoIP apps usage during the initial stage of the coronavirus pandemic. *Front Psychol.* (2021) 12. doi: 10.3389/fpsyg.2021.620739

18. Hunt MG, Marx R, Lipson C, Young J. No more FOMO: limiting social media decreases loneliness and depression. *J Soc Clin Psychol.* (2018) 37:751–68. doi: 10.1521/jscp.2018.37.10.751

19. Lee HY, Jamieson JP, Reis HT, Beevers CG, Josephs RA, Mullarkey MC, et al. Getting fewer "likes" than others on social media elicits emotional distress among victimized adolescents. *Child Develop.* (2020) 91:2141–59. doi: 10.1111/cdev.13422

20. Craig W, Boniel-Nissim M, King N, Walsh SD, Boer M, Donnelly PD, et al. Social media use and cyber-bullying: a cross-national analysis of young people in 42 countries. *J Adolesc Health.* (2020) 66(6, Supplement):S100–S8. doi: 10.1016/j.jadohealth.2020.03.006

21. Woods HC, Scott H. #Sleepyteens: Social media use in adolescence is associated with poor sleep quality, anxiety, depression and low self-esteem. *J Adoles.* (2016) 51:41–9. doi: 10.1016/j.adolescence.2016.05.008

22. Kelly Y, Zilanawala A, Booker C, Sacker A. Social media use and adolescent mental health: findings from the UK Millennium Cohort Study. *E Clin Med.* (2018) 6:59–68. doi: 10.1016/j.eclinm.2018.12.005

23. Chen M, Xu Q, Cui M. Sleep problems, attention, and classroom learning behaviors of Chinese elementary school children: the moderating role of gender. *School Psychol Int.* (2021) 42:341–57. doi: 10.1177/0143034321993502

24. Sivertsen B, Harvey AG, Lundervold AJ, Hysing M. Sleep problems and depression in adolescence: results from a large population-based study of Norwegian adolescents aged 16–18 years. *Eur Child Adoles Psych.* (2014) 23:681–9. doi: 10.1007/s00787-013-0502-y

25. Trifiro BM, Gerson J. Social media usage patterns: research note regarding the lack of universal validated measures for active and passive use. *Soc Media Soc.* (2019) 5. doi: 10.1177/2056305119848743

26. Bekalu MA, McCloud RF, Viswanath K. Association of social media use with social well-being, positive mental health, and self-rated health: disentangling routine use from emotional connection to use. *Health Educ Behav.* (2019) 46:69S—80S. doi: 10.1177/1090198119863768

27. Geirdal AØ, Ruffolo M, Leung J, Thygesen H, Price D, Bonsaksen T, et al. Mental health, quality of life, wellbeing, loneliness and use of social media in a time of social distancing during the COVID-19 outbreak. A cross country comparative study. *J Mental Health.* (2021) 30:148–55. doi: 10.1080/09638237.2021.1875413

28. Gao J, Zheng P, Jia Y, Chen H, Mao Y, Chen S, et al. Mental health problems and social media exposure during COVID-19 outbreak. *PLoS ONE.* (2020) 15:e0231924. doi: 10.1371/journal.pone.0231924

29. Kleppang AL, Steigen AM, Ma L, Søberg Finbråten H, Hagquist C. Electronic media use and symptoms of depression among adolescents in Norway. *PLoS ONE.* (2021) 16:e0254197. doi: 10.1371/journal.pone.0254197

30. Keles B, McCrae N, Grealish A. A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents. *Int J Adoles Youth.* (2020) 25:79–93. doi: 10.1080/02673843.2019.1590851

31. Petropoulos Petalas D, Konijn EA, Johnson BK, Veldhuis J, Bij de Vaate NAJD, Burgers C, et al. Plurality in the measurement of social media use and mental health: an exploratory study among adolescents and young adults. *Soc Media Society.* (2021) 7. doi: 10.1177/20563051211035353

32. Blomfield Neira CJ, Barber BL. Social networking site use: linked to adolescents' social self-concept, self-esteem, and depressed mood. *Austral J Psychol.* (2014) 66:56–64. doi: 10.1111/ajpy.12034

33. Najafi M, Foladjang M. The relationship between self- efficacy and mental health among high school students. *Clin Psychol Pers.* (2007) 5:69–83. Available online at: http://cpap.shahed.ac.ir/article_2599.html?lang=en

34. Abdel-Khalek AM, Lester D. The association between religiosity, generalized self-efficacy, mental health, and happiness in Arab college students. *Pers Indiv Diff.* (2017) 109:12–6. doi: 10.1016/j.paid.2016.12.010

35. Parto M, Besharat MA. The direct and indirect effects of self- efficacy and problem solving on mental health in adolescents: assessing the role of coping strategies as mediating mechanism. *Procedia Soc Behav Sci.* (2011) 30:639–43. doi: 10.1016/j.sbspro.2011.10.124

36. Calandri E, Graziano F, Rollé L. Social media, depressive symptoms and wellbeing in early adolescence. The moderating role of emotional self-efficacy and gender. *Front Psychol.* (2021) 12:1871. doi: 10.3389/fpsyg.2021.660740

37. Li Y. Upward social comparison and depression in social network settings. *Internet Res.* (2019) 29:46–59. doi: 10.1108/IntR-09-2017-0358

38. Bakken A. Ungdata 2021. *Nasjonale Resultater [Ungdata 2021: National results]*. Oslo: NOVA, OsloMet. NOVA Report 8/21. (2021).

39. Kandel DB, Davies M. Epidemiology of depressive mood in adolescents: an empirical study. *Arch Gen Psych.* (1982) 39:1205–12. doi: 10.1001/archpsyc.1982.04290100065011

40. Derogatis LR, Lipman RS, Rickels K, Uhlenhuth EH, Covi L. The Hopkins Symptom Checklist (HSCL): a self-report symptom inventory. *Behav Sci.* (1974) 19:1–15. doi: 10.1002/bs.3830190102

41. Kleppang AL, Steigen AM, Finbråten HS. Using Rasch measurement theory to assess the psychometric properties of a depressive symptoms scale in Norwegian adolescents. *Health Qual Life Outcomes.* (2020) 18:127. doi: 10.1186/s12955-020-01373-5

42. Statistics Norway. *Classification of Centrality*. Oslo: Statistics Norway. (2020). Available online at: https://www.ssb.no/en/klass/klassifikasjoner/128 (accessed October 1, 2022).

43. Schwarzer R, Jerusalem M. Generalized self-efficacy scale. In: Weinman J, Wright S, Johnston M, editors. *Measures in Health Psychology: A User's Portfolio.* Winsor, United Kingdom: Nfer-Nelson. (1995). p. 35–7.

44. Luszczynska A, Scholz U, Schwarzer R. The general self-efficacy scale: Multicultural validation studies. *J Psychol Interdisc Appl.* (2005) 139:439–57. doi: 10.3200/JRLP.139.5.439-457

45. Røysamb E. *Adolescent risk making: behaviour patterns and the role of emotions and cognitions.* (PhD thesis). Oslo, Norway: University of Oslo. (1997).

46. Posadzki P, Stockl S, Musonda P, Tsouroufli M. A mixed-method approach to sense of coherence, health behaviors, self-efficacy and optimism: towards the operationalization of positive health attitudes. *Scand J Psychol.* (2010) 51:246–52. doi: 10.1111/j.1467-9450.2009.00764.x

47. Leganger A, Kraft P, Røysamb E. Perceived self-efficacy in health behaviour research: Conceptualisation, measurement and correlates. *Psychol Health.* (2000) 15:51–69. doi: 10.1080/08870440008400288

48. Bonsaksen T, Lerdal A, Heir T, Ekeberg Ø, Skogstad L, Grimholt TK, et al. General self-efficacy in the Norwegian population: differences and similarities between sociodemographic groups. *Scand J Public Health.* (2019) 47:695–704. doi: 10.1177/1403494818756701

49. Steigen AM, Finbraaten H, Kleppang A. Using Rasch analysis to assess the psychometric properties of a five-item version of the General Self-Efficacy Scale in adolescents. *Int J Environ Res Public Health.* (2022) 19:3082. doi: 10.3390/ijerph19053082

50. Lumley T, Diehr P, Emerson S, Chen L. The importance of the normality assumption in large public health data sets. *Annu Rev Public Health.* (2002) 23:151–69. doi: 10.1146/annurev.publhealth.23.100901.140546

51. Cohen J. A power primer. *Psychol Bull.* (1992) 112:155–9. doi: 10.1037/0033-2909.112.1.155

52. Hocking RR. *Methods and Applications of Linear Models: Regression and the Analysis of Variance.* Hoboken, NJ: Wiley. (2013).

53. Vidal C, Lhaksampa T, Miller L, Platt R. Social media use and depression in adolescents: a scoping review. *Int Rev Psych.* (2020) 32:235–53. doi: 10.1080/09540261.2020.1720623

54. Valkenburg PM, Meier A, Beyens I. Social media use and its impact on adolescent mental health: an umbrella review of the evidence. *Curr Opin Psychol.* (2022) 44:58–68. doi: 10.1016/j.copsyc.2021.08.017

55. Ivie EJ, Pettitt A, Moses LJ, Allen NB. A meta-analysis of the association between adolescent social media use and depressive symptoms. *J Affect Disord.* (2020) 275:165–74. doi: 10.1016/j.jad.2020.06.014

56. Fisher BW, Gardella JH, Teurbe-Tolon AR. Peer cybervictimization among adolescents and the associated internalizing and externalizing problems: a meta-analysis. *J Youth Adoles.* (2016) 45:1727–43. doi: 10.1007/s10964-016-0541-z

57. Hartanto A, Quek FYX, Tng GYQ, Yong JC. Does social media use increase depressive symptoms? A reverse causation perspective. *Front Psych.* (2021) 12. doi: 10.3389/fpsyt.2021.641934

58. Herring SC, Kapidzic S. Teens, gender, and self-presentation in social media. In: Wright J, editor. *International Encyclopedia of Social and Behavioral Sciences*. 2 ed. Amsterdam: Elsevier. (2015). p. 146–52.

59. Wang R, Bianchi SM, Raley SB. Teenagers' internet use and family rules: a research note. *J Marriage Fam.* (2005) 67:1249–58. doi: 10.1111/j.1741-3737.2005.00214.x

60. Hjetland GJ, Schønning V, Hella RT, Veseth M, Skogen JC. How do Norwegian adolescents experience the role of social media in relation to mental health and well-being: a qualitative study. *BMC Psychol.* (2021) 9:78. doi: 10.1186/s40359-021-00582-x

61. Primack BA, Bisbey MA, Shensa A, Bowman ND, Karim SA, Knight JM, et al. The association between valence of social media experiences and depressive symptoms. *Depress Anx.* (2018) 35:784–94. doi: 10.1002/da.22779

62. Bandura A, Caprara GV, Barbaranelli C, Gerbino M, Pastorelli C. Role of affective self-regulatory efficacy in diverse spheres of psychosocial functioning. *Child Dev.* (2003) 74:769–82. doi: 10.1111/1467-8624.00567

63. Tak YR, Brunwasser SM, Lichtwarck-Aschoff A, Engels RCME. The prospective associations between self-efficacy and depressive symptoms from early to middle adolescence: a cross-lagged model. *J Youth Adoles.* (2017) 46:744–56. doi: 10.1007/s10964-016-0614-z

64. Frøyland LR. Undata - Local youth surveys. *Documentation on the Survey Variables [Norwegian: Ungdata - lokale ungdomsundersøkelser Dokumentasjon av variablene i spørreskjemaet]*. Oslo: NOVA. (2017).

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Maximizing the positive and minimizing the negative: Social media data to study youth mental health with informed consent

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Social media usage impacts upon the mental health and wellbeing of young people, yet there is not enough evidence to determine who is affected, how and to what extent. While it has widened and strengthened communication networks for many, the dangers posed to at-risk youth are serious. Social media data offers unique insights into the minute details of a user's online life. Timely consented access to data could offer many opportunities to transform understanding of its effects on mental wellbeing in different contexts. However, limited data access by researchers is preventing such advances from being made. Our multidisciplinary authorship includes a lived experience adviser, academic and practicing psychiatrists, and academic psychology, as well as computational, statistical, and qualitative researchers. In this Perspective article, we propose a framework to support secure and confidential access to social media platform data for research to make progress toward better public mental health.

KEYWORDS

social media, data protection, research ethics, risk, Facebook

Introduction

The viewing of self-harm-related images and posts have been cited as factors in the suicide of young people across the world (1). Not all social media use is detrimental to mental health however, and it is increasingly harnessed to provide support and even suicide prevention strategies (2, 3).

Testimony to US Congress in October 2021 by a former Facebook employee, provided evidence that the social media platform concealed internal research findings regarding the potential negative impact of its Instagram platform on some youth (4). Furthermore, social media platforms have been blocking access to data by external researchers, potentially delaying the development of life-saving advances and discoveries (5). Social media data, for example, offers the scientific community unique insights into the details of a person's digitally mediated life. Near-real-time access to data paired with the informed consent of the individual, could provide many positive opportunities in a clinical setting.

Following the Cambridge Analytica scandal of 2018, where the personal data of millions of Facebook users was harvested without their consent, the platform tightened access to its Application Programming Interface (API), which served as the main tool by which legitimate researchers collected behavioral and digital trace data (6). Facebook's current complex and lengthy guidelines for data access are aimed at commercial organizations and centred on a notion of "*enhancing user experience*," including by means of targeted personal advertising (7). Research does not usually intend to improve the individual "user experience," but instead has wider societal implications. It is important to note that in light of prior misuses of Facebook's API, all use of the API is required to be verified by Facebook and must meet Facebook's own guidelines.

This difference in focus by researchers can result in lack of access to platform products offered widely to the commercial sector, such as the open authentication protocol allowing login and access to user content *via* a user's Facebook login. This disparity in data accessibility between commercial and academic interests, with commercial gain prioritized over research for public benefit, raises a vital question for scientific research and data ownership. How might we conduct independent, academic research into the impact of social media use on behavioral health and wellbeing when access to data is so limited?

Researchers who try to develop expensive and difficult to maintain bespoke data collection pipelines (i.e., systems designed to regularly extract and store data from consented users), compliant with the terms of service specified by a platform to collect publicly available data, are often unsuccessful. Their requests are reviewed by the platform, and a decision is made stating that the terms are violated as they do not enhance the *"user experience."* There is no independent review or appeals process external to the organization with limited engagement and consultation with academic or lived experience researchers to develop systems that meet the needs of all parties.

Moreover, researchers encounter increasingly negative scenarios when they attempt to access social media data from fully consented and ethically approved studies with active participants. Even when informed user consent is carefully documented, social media platforms do not permit (or have technical roadblocks) to data access. As an example, our US colleagues created a system for the consented donation of online data (OurDataHelps.org), to screen for suicide risk and varied mental health diagnoses using natural language processing (3, 8). By January 2021, more than 4,000 individuals had provided self-report mental health data and social media content, yet the agreed access and collection of data was revoked by the platforms. There were neither complaints by the participants nor breaches of data, the platforms simply made it impossible for this project to continue despite a long track record of qualified support of peer-reviewed research by leading Universities.

For us the answer is simple. While users must provide consent to social media platforms for the processing of their personal data, it should be for the user to decide how their other data is processed and used (9). Barriers should not be placed in the way of users making informed decisions about this.

Such a view is supported by legislation and data regulation. In the European Union and the European Economic Area, the use of personal data is regulated by the General Data Protection Regulation 2016/679 - commonly known as GDPR - which poses a number of conditions under which data processing may be considered lawful. The most transparent way for academics to process data and comply with the regulations is by obtaining informed consent.

GDPR also specifies that data processing may be lawful if it is "necessary for the performance of a task carried out in the public interest." Since it is generally straightforward to defend academic research by accredited Universities as pertaining to public interest, data collection, analysis, and publication for scientific purposes is protected by the GDPR. This is particularly the case when participants have provided informed consent for the use of their data. Yet social media platforms are using presumed incompatibility with data privacy and accessibility as a justification to deflect or deny qualified researcher access requests.

The default position of academic study is to rely heavily on self-reported social media use which is known to be an inaccurate proxy for logged media use (10). Alternatively, participants are burdened with the unwieldy task of requesting and accessing a copy of their data and providing this to researchers (11). The systems the platforms provide to the user, while compliant with the law, are not user friendly for this purpose, which presents the researcher with complications for data completeness and participant retention. It is imperative that we move beyond self-report and utilize behavioral data from platforms including Apple iOS, Google Android, Facebook, Instagram, TikTok, Twitter and YouTuben to understand more objectively how young people are interacting online and how and when this affects their mental wellbeing, in ways that are acceptable to participants.

To address the concerns of the research community about users' safety and security, the UK government's Online Harms White Paper (12), released in 2020, pledged to provide "researchers with access to company data to support research into online harms." The government proposal also included a 2% "turnover tax" levy on the UK revenues of major technology companies to fund independent research and training packages for clinicians, teachers and other professionals working with children and young people, though this has since been reversed with the Organization for Economic Co-operation and Development (OECD) taxation agreement earlier this year.

Neither recommendation has been realized. Instead, both proposals have been removed from the delayed Online Safety Bill, to be replaced only by a requirement for the government-approved regulatory Office of Communications (OFCOM) to prepare a report explaining how independent researchers are "(a)…currently able to obtain information from providers of regulated services to inform their research, (b) exploring the legal and other issues which currently constrain the sharing of information for such purposes, and (c) assessing the extent to which greater access to information for such purposes might be achieved" (13).

A framework of recommendations

The UK government's Online Harms White Paper's (12) suggested introduction of a voluntary best practice frameworks has not been included in the Draft Online Safety Bill (13), and would not ensure social media platforms met their ethical responsibilities (e.g., data protection, participant health and safety).

Over the last 20 years, social media platforms have been able to develop their own rules as to what, how and why an individual, organization or researcher can access user data. Often these rules change without notice, without prior notification and irrespective of the potential harm this may cause. Therefore, we are proposing a framework to facilitate regulated and monitored access for researchers to social media platform data in order to make long-term progress toward public mental health.

Our framework has four core elements and a cross-cutting theme integral to each stage (refer to Figure 1).

Co-production with user and stakeholder groups is the cross-cutting theme embedded and incorporated into each element of the framework. Using established public and patient involvement standards (e.g., UK Standards for Public Involvement, NIHR: https://sites.google.com/nihr.ac.uk/pi-standards/home), researchers should work collaboratively with those with lived experience, carers and members of the public to first identify the research priorities and then co-produce research protocols and methods.

Research need

Qualified researchers at accredited Universities intending to use social media data to understand and improve youth mental health, should co-produce their research with patients, carers and members of the public. Researchers shall undertake user-centred engagement in line with established public and patient involvement model criteria throughout the study; justify the rationale for data access and engage data owners in the proposed research (14). The data owner and user-group should also review and approve analysis plans to ensure the approach is acceptable, ethically-sound, feasible and of value.

Ethical approval and informed consent

Participants should always be empowered to understand why and how their data will be used for research. This should be in accessible and acceptable formats which user groups co-produce with researchers. Ethically-approved informed consent procedures will state exactly what is being collected, how it will be processed and how results will be reported. This will include clear accessible guidance on how data will be managed following GDPR.

Data access and analysis

Certain social media data inherently cannot be fully anonymised due to free-text and use of images/videos. Therefore, robust data governance guidelines and well-defined individual institutional accountability should be established, on a par with current protocols for medical research. This would include analyzing data in a Secure Research Environment (SRE), where access is intensively monitored and controlled. Data owners should agree data sharing agreements with SRE providers. Exemplars in the UK include the Office for National Statistics Secure Research Service (SRS), which records each interaction with the data and restricts what researchers might do with the data. Having a trained service user group with lived experience involved in qualitative data analysis can realign researchers' misinterpretations and challenge the ways in which findings are reported adding value to the products of research analysis.

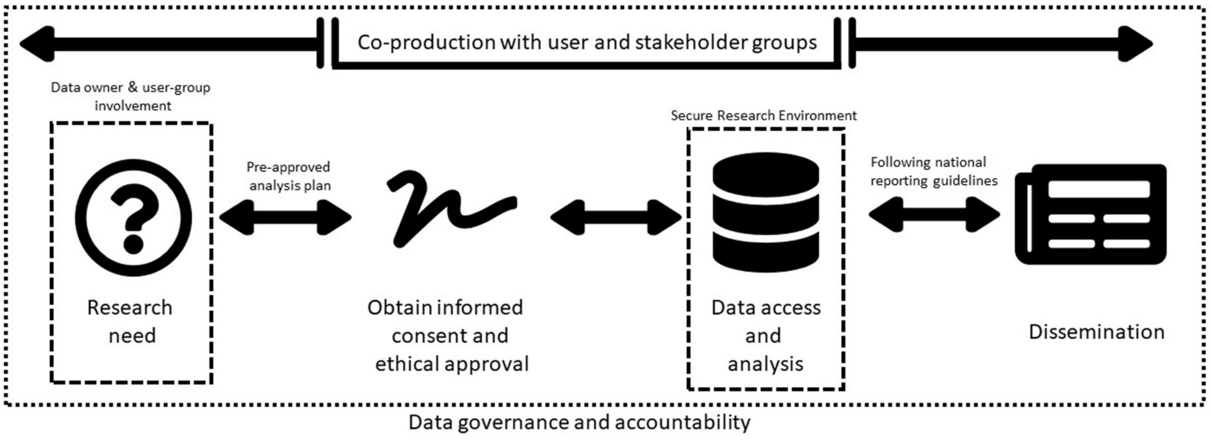

FIGURE 1
Proposed framework to regulate and monitor researchers' access to social media platform data.

Open dissemination

A Registered Report format is recommended, which *via* standardization, would improve the peer review process to be conducted before data collection and public dissemination of research findings. Lived experience advisers or service user researchers should be included in the authorship of documents, briefings and research papers arising. This would promote better accessibility, transparency and collaboration for the public, academic community and other interested groups in accordance with the Open Science Framework.

Conclusions

Gaining informed consent for social media data access to study youth mental health has the potential for significant benefits in public mental health. Data collected *via* social media platforms provide us with a unique opportunity to gather vital insights into participants' actions and activities. This unparalleled access will help researchers understand the intricate social constructs of user interactions, perceptions, mental state and health.

At present, the poorly defined term "enhancing user experience" is the main factor that social media platforms apply in determining if access is granted. However, accredited researchers' use of social media platform data does not usually improve user "experience" in the commercial sense, rather it has the potential for wider positive public benefits which are unlikely to be of primary interest for social media platforms.

Tackling harmful and negative content is a global problem, but one solution is to provide access for researchers to understand the problem. It is important that we unlock social media data's potential for research and leverage the data for societal good. We hope this framework will be a "call to action" to stimulate social media platforms, policy makers and researchers to make positive changes by collaborative working.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: Perspective article. Original contribution relates to https://gtr.ukri.org/projects?ref=MR%2FS020365%2F1.

Author contributions

DL, AB, BC, KT, SB-F, ML, AW, TF, and RD contributed to conception and planning of this perspective article. DL and RD wrote the first draft of the manuscript. All authors contributed to sections of the manuscript according to expertise, editing, revision, and approved the submitted version.

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Conflict of interest

AW was Chair of the Board of the American Association of Suicidology. DO was a Board member for the Association for Child and Adolescent Mental Health. TF consults to place2Be a third sector organization that provides mental health to schools and is the Vice Chair of the Association for Child and Adolescent Mental Health.

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.

Publisher's note

References

1. Luxton DD, June JD, Fairall JM. Social media and suicide: a public health perspective. *Am J Public Health.* (2012) 102(Suppl 2):S195–200. doi: 10.2105/AJPH.2011.300608

2. Sedgwick R, Epstein S, Dutta R, Ougrin D. Social media, internet use and suicide attempts in adolescents. *Curr Opin Psychiatry.* (2019) 32:534–41. doi: 10.1097/YCO.0000000000000547

3. Coppersmith G, Ngo K, Leary R, Wood A. "Exploratory analysis of social media prior to a suicide attempt." In: *Proceedings of the 3rd Workshop on Computational Linguistics and Clinical Psychology.* (2016). doi: 10.18653/v1/W16-0311

4. Paul K. *Facebook Whistleblower's Testimony Could Finally Spark Action in CONGRESS.* Guardian Online (2021). Available online at: https://www.theguardian.com/technology/2021/oct/05/facebook-frances-haugen-whistleblower-regulation (accessed October 15, 2021).

5. Mahase E. Social media companies should be forced to share data for harms and benefits research, say psychiatrists. *BMJ.* (2020) 368:m209. doi: 10.1136/bmj.m209

6. Mancosu M, Vegetti F. What you can scrape and what is right to scrape: A proposal for a tool to collect public facebook data. *Soc Media Soc.* (2020) 6:2056305120940703. doi: 10.1177/2056305120940703

7. Dwivedi YK, Ismagilova E, Hughes DL, Carlson J, Filieri R, Jacobson J, et al. Setting the future of digital and social media marketing research: Perspectives and research propositions. *Int J Informat Manage.* (2021) 59:102168. doi: 10.1016/j.ijinfomgt.2020.102168

8. Kelly DL, Spaderna M, Hodzic V, Coppersmith G, Chen S, Resnik P. Can language use in social media help in the treatment of severe mental illness? *Curr Res Psychiatry.* (2021) 1:1–4. doi: 10.46439/Psychiatry.1.001

9. Rieger A, Gaines A, Barnett I, Baldassano CF, Connolly Gibbons MB, Crits-Christoph P. Psychiatry outpatients' willingness to share social media posts and smartphone data for research and clinical purposes: Survey study. *JMIR Form Res.* (2019) 3:e14329. doi: 10.2196/14329

10. Parry DA, Davidson BI, Sewall CJR, Fisher JT, Mieczkowski H, Quintana DS. A systematic review and meta-analysis of discrepancies between logged and self-reported digital media use. *Nat Hum Behav.* (2021) 5, 1535–47. doi: 10.31234/osf.io/f6xvz

11. Huckvale K, Venkatesh S, Christensen H. Toward clinical digital phenotyping: a timely opportunity to consider purpose, quality, and safety. *NPJ Digit Med.* (2019) 2:88. doi: 10.1038/s41746-019-0166-1

12. *Online Harms White Paper: Full Government Response to the Consultation.* London (2020). Available online at: https://www.gov.uk/government/consultations/online-harms-white-paper/outcome/online-harms-white-paper-full-government-response

13. Draft Online Safety Bill Part 4. *OFCOM's powers and duties in relation to regulated services, Chapter 7 - Committees, research and reports, section.* (2021).

14. Bye A, Carter B, Leightley D, Trevillion K, Liakata M, Branthonne-Foster S, et al. Observational prospective study of social media, smartphone use and self-harm in a clinical sample of young people: Study protocol. *BMJOpen.* (2022) 2022:069748.

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A bidirectional association between smartphone addiction and depression among college students: A cross-lagged panel model

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Background: Smartphone addiction (SA) is associated with adverse consequences, especially for freshmen. Evidence indicates that SA is associated with depression, and it is necessary to conduct a longitudinal study to explore the association further.

Methods: SA (measured by the Smartphone Addiction Scale-Short Version) and depression (measured by the Zung's Self-Rating Depression Scale) among 1,186 freshmen were surveyed at baseline and a respective 12-month follow-up for each participant. The application of a cross-lagged panel model approach (CLPM) revealed an association between SA and depression after adjusting for demographic variables.

Results: The CLPM results showed a significant path from baseline SA to follow-up depression ($\beta = 0.08$, $P < 0.001$) and a significant path from baseline depression to follow-up SA ($\beta = 0.08$, $P < 0.001$). Compared with the overall cross-lagged model, the cross-lagged coefficient of the path from baseline SA to follow-up depression increased in the female group ($\beta = 0.10$, $P = 0.015$), and the cross-lagged coefficient of the path from baseline depression to follow-up SA also increased significantly ($\beta = 0.15$, $P < 0.001$). In contrast, the cross-lagged model in the male group showed no predictive effect between SA and depression ($P > 0.05$).

Conclusions: The current study showed a significant bidirectional association between smartphone addiction and depression among freshmen, but only in the female population.

KEYWORDS

smartphone addiction, depression, college students, longitudinal study, cross-lagged panel model (CLPM)

1. Introduction

Smartphone addiction (SA) is characterized by excessive attention and uncontrolled dedication to one's smartphone (1). It has been observed that SA has worryingly increased worldwide in recent years. Zhong et al. (2) conducted a systematic review and found that the prevalence of SA among Asian medical students was 41.93%. Meng et al. (3) found that the global pooled prevalence of SA was 34.5% among college and high school student populations over the last 2 years. In addition, numerous studies have shown that SA is associated with several psychiatric comorbidities, including depression, anxiety, autism spectrum disorder and suicide attempt (4–7). Depression is also common among adolescents. A recent systematic review reported a global prevalence of depression among adolescents of 34% (95% CI: 30–38%), with a higher prevalence among females than males (8). Depression can have serious adverse health consequences for adolescents and may increase the risk of suicide attempts, substance abuse, anxiety disorders, and comorbid somatic disorders (9). Freshmen are a particular population transitioning from high school to college, facing new physical and interpersonal environments, and prone to mental health problems (10). After leaving the high school environment with a heavy academic load and little free time and entering relatively free college life, freshmen also have more time to use smartphones. In addition, they may become heavily dependent on smartphones, either as a tool to stay in touch with family and friends or as a necessary tool for studying and living in a new environment (11).

Different studies have provided preliminary empirical support for the association between SA and depression. In cross-sectional studies, some suggest that SA may be a risk factor for depression (12, 13), while others suggest that depression may be a risk factor for SA (14, 15). Li et al. pooled 21 studies for meta-analysis and showed that SA was weakly to moderately positively associated with depression (r=0.36) (16). Several hypotheses or approaches have been proposed to explain the interrelationship between SA and depression. The first is the Compensatory Internet Use Theory (CIUT) (17). This theory states that individuals' use of smartphones is a means for them to cope with painful emotional states and to access social needs that may not be met in the real world (17). In this model, depressed individuals have difficulty feeling pleasure gained from social interactions but tend to use their phones more frequently as an adaptive coping mechanism in difficult situations and may be prone to SA (18, 19). The second is the upward social comparison hypothesis, which refers to people comparing themselves with those they perceive to be in a more favorable position (20). For this hypothesis, repeated exposure to idealized information during smartphone use may lower the user's self-esteem, trigger depression, and enhance depression over time (21). In addition, Samra et al. (22) noted that females used social media more problematically and compared themselves more negatively to others on social media than males. This suggests the need to pay attention to gender differences while exploring the relationship between SA and depression.

It has been reported that female students report a higher prevalence of depressive symptoms than male students (9). Crockett et al. (23) found that females have more depressive moods but fewer problems with concentration and psychomotor retardation/agitation than males. Albursan et al. (24) indicated that although female students were more likely to use smartphones, the effect of over-reliance on smartphones on academic achievement appears to be more pronounced among male students. Zhu et al. (25) found that depression predicted Internet addiction only among males but not among females, suggesting that the bidirectional predictive relationship between Internet addiction and depression may depend on gender. Considering that the above study found gender differences in addictive behaviors and depressive symptoms, it is necessary to further explore the role of gender in the longitudinal association of SA and depression.

Longitudinal survey analysis to test these hypotheses concerning the potential etiological association between SA and depression will undoubtedly be valuable. Zhou et al. (26) conducted a 6-month follow-up of 313 high school students and found that depression unidirectionally predicted SA. Chen et al. (27) conducted a 9-month follow-up of 308 Hong Kong university students and found that the growth of SA was positively associated with depression. Published longitudinal studies are limited in several ways, as follows, relatively small sample sizes, short follow-up intervals, no studies have focused on the stability of SA or depression, and no consideration of the role of gender as an essential factor in the relationship. In light of the limitations of published studies, a longitudinal study is warranted to explore the association between SA and depression further. The present study aims to test the hypothesized bidirectional association between smartphone addiction and depression among freshmen using the CLPM model and to explore the role of gender in this association.

2. Methods

2.1. Participants

This is a one-year prospective study. In September 2020, we recruited 1226 freshmen from a medical college in Hefei, Anhui Province, China. An electronic questionnaire was used, with the investigator providing a QR code between classes and students scanning the code with their smartphones to fill out the questionnaire. Among the included respondents, 1,186 (96.47%) also completely responded to the questions relevant to the present study in a respective follow-up survey after 12 months. The questionnaire completion was anonymous, and data from the two surveys were matched according to a unique code assigned to each student. Informed consent was obtained from every participant prior to two questionnaire surveys. The Research Ethics Committee has approved this study of the Anhui Medical University (No. 20190495).

2.2. Measures

The data collected in the present study included socio-demographics, living habits, and health conditions. The variables examined in the socio-demographic section included gender, age, and their parents' education level (bachelor degree or higher). The lifestyle factors included body-mass index (BMI), daily exercise time (hours), daily smartphone use time (hours), and sleep time per night (hours). The health conditions included smartphone addiction (SA) and depression severity, measured by the Smartphone Addiction Scale-Short Version (SAS-SV) (Supplementary Tables 1, 2) and the Zung's Self-Rating Depression Scale (SDS) (Supplementary Tables 3, 4), respectively.

The Smartphone Addiction Scale-Short Version (SAS-SV) consisted of 10 symptoms of excessive smartphone use (28). Six experts selected 10 items of this short version from the original 33-item SAS. Each item was scored on a six-point Likert scale, and a higher total score indicates a more severe level of smartphone addiction. The widely used SAS-SV cut-off scores of $\geq$31 for males and $\geq$33 for females were used as proposed by the scale developers

(28). We used the version translated by Xiang et al., which has been shown in previous studies to have good reliability and validity of SAS-SV in Chinese populations (29). In this study, *Cronbach's* α for SAS-SV at baseline and follow-up surveys were 0.83 and 0.89, respectively. Confirmatory factor analysis showed an acceptable model fit of SAS-SV at the baseline survey ($\chi 2/df = 12.83$, CFI $=0.87$, GFI $=0.92$, and RMSEA $= 0.10$) and at the follow-up survey ($\chi 2/df = 19.74$, CFI $=0.88$, GFI $=0.88$, and RMSEA $= 0.13$).

Zung's Self-Rating Depression Scale (SDS) has been widely used to assess depression during the past week (30). It consists of 20 self-rated questions, each item rated on a 4-point scale ranging from 1 (a little of the time) to 4 (most of the time). The total score was acquired by multiplying the raw score by 1.25. A higher total score indicates a more severe level of depression. An SDS score of 50 (raw score = 40) suggests clinically significant symptoms (31). Many previous studies had used the Chinese versions of SDS (32) to evaluate the depression symptoms in Chinese population including adolescents (33). In this study, *Cronbach's* α for SDS at baseline and follow-up surveys were 0.80 and 0.84, respectively. Confirmatory factor analysis showed that the $\chi 2/df$, CFI, GFI, and RMSEA of SDS at baseline survey were 7.47, 0.75, 0.88, and 0.07, respectively; and the $\chi 2/df$, CFI, GFI, and RMSEA at follow-up survey were 19.08, 0.62, 0.68, and 0.12, respectively.

2.3. Statistical procedures

Descriptive characteristics were investigated at baseline between the responders and non-responders (Table 1). Categorical variables were reported as frequency (percentages), and continuous variables were reported as means (standard deviations).

Univariate differences in demographic variables frequencies and rates in individuals with SA and depression were tested with the Chi-square test. Adjusted odds ratios (ORs) and their 95% CIs for individuals with SA or depression and demographic groups were estimated using a binary logistic regression (Enter) model adjusted for confounding effects. For the binary logistic regression (Enter) model, the dependent variables were the status of SA or depression (Yes or No), and the independent variables were age, biological gender, parental education level, maternal education level, and BMI.

Furthermore, AMOS 26.0 was used to calculate structural equation models (SEM) in the cross-lagged panel model (CLPM) design, including the follow-up sample (n = 1,186) to examine possible bidirectional effects between SAS-SV scores and SDS scores. Model fit was evaluated using χ^2 index (χ^2/df), comparative fit index (CFI), goodness-of-fit index (GFI), and root-mean-square error of approximation (RMSEA). Eventually, we performed a multi-group analysis by gender. Statistical significance was accepted at $P < 0.05$ in all analyses.

3. Results

3.1. Demographics

Characteristics between responders and non-responders of the study sample are presented in Table 1. There were 1,186 (96.74%) participants responding at follow-up. No significant differences were found between participants who responded to the baseline survey only and those who responded to both in terms of socio-demographics, living habits and health conditions. In view of this result, we focused mainly on reporting data from participants who responded to both surveys ($n = 1{,}186$) in the following sections.

3.2. The rates and associated factors of SA and depression at baseline and follow-up surveys

The rates of baseline SA and depression were 32.0% (95% CI: 29.4%, 34.7%) and 10.7% (95% CI: 8.9%, 12.5%), respectively; they increased to 52.5% (95% CI: 49.7%, 55.4%) and 28.2% (95% CI: 25.7%, 30.8%) at follow-up, respectively (Tables 2, 3).

SA was more prevalent among males than in females, both at baseline and follow-up survey [aOR at baseline: 1.93 (95% CI: 1.49, 2.50); aOR at follow-up: 1.30 (95% CI: 1.03, 1.66)]. Depression was more prevalent among females at baseline [aOR: 1.73 (95% CI: 1.16, 2.56)]; but more prevalent among males at follow-up [aOR: 1.56 (95% CI: 1.20, 2.03)] (Tables 2, 3).

A strong cross-sectional association was observed between SA and depression for both the baseline and follow-up surveys. The adjusted OR (aOR) values after controlling for demographics were 2.88 (95% CI: 1.97, 4.23) and 1.65 (95% CI: 1.27, 2.14) for the baseline and follow-up surveys, respectively (Tables 2, 3).

3.3. The stability and new incidence of SA and depression over 12 months

Regarding the stability of SA and depression over 12 months, we observed that 67.1% (95% CI: 62.4%, 71.9%) of the participants in the baseline still scored over the SAS-SV threshold after 12 months; in addition, 60.6% (95% CI: 52.0%, 69.2%) of the participants in the cohort with baseline depressive symptoms still scored over the SDS threshold in the follow-up survey (Table 3).

Regarding the new incidence of SA and depression over 12 months, 45.7% (95% CI: 42.2%, 49.1%) of participants without baseline SA scored over the SAS-SV threshold after 12 months; in the follow-up survey, 24.4% (95% CI: 21.8%, 27.0%) of the participants without baseline depressive symptoms scored over the SDS threshold (Table 3).

3.4. The CLPM analysis between severities of SA and depression

A well-fitted CLPM between severities of SA and depression was revealed by SEM analysis using continuous data, based on SAS-SV and SDS scores. The χ^2 index (χ^2/df) was 32.16 ($\chi^2 = 32.16$, $df = 1$, $P < 0.001$), CFI $=0.94$, GFI $=0.99$, and RMSEA $= 0.16$ (95% CI: 0.12, 0.21). All of these observed fit-indices reached the recommended cut-off values based on previous studies, except RMSEA. After adjusting for the effect of the covariates, although the severity of SA in the follow-up survey was predicted by baseline depression severity (path coefficient: 0.08; $P = 0.008$), the path coefficient was smaller than the predictive effect of the baseline SA severity relative to follow-up SA severity (0.26, $P < 0.001$) and the cross-sectional association between

TABLE 1 Descriptive characteristics comparing groups responding at baseline only, or both surveys.

	Participants who responded to baseline survey only ($N = 1226$) Mean (SD) or N (%)	Participants who responded to both surveys ($N = 1186$) Mean (SD) or N (%)	*P* value
Socio-demographics			
Age, years[a]	18.08 (2.45)	18.08 (2.22)	0.979
Gender, male[b]	587 (47.9)	566 (47.7)	0.939
Parental education level (Bachelor's degree or above)[b]	273 (22.3)	262 (22.1)	0.917
Maternal education level (Bachelor's degree or above)[b]	176 (14.4)	170 (14.3)	0.988
Living habits			
Body-Mass Index[a]	21.63 (3.52)	21.64 (3.52)	0.948
Daily exercise time, hours[a]	1.17 (0.78)	1.17 (0.78)	0.931
Daily smartphone use time, hours[a]	3.77 (2.02)	3.76 (2.01)	0.885
Sleep time per night, hours[a]	7.18 (1.05)	7.18 (1.05)	0.970
Health conditions			
SAS-SV scores[a]	27.85 (7.63)	27.66 (7.31)	0.528
SDS scores[a]	41.50 (8.09)	41.62 (8.12)	0.732

Values are percentages for categorical variables, means for continuous variables and P value. SD, standard deviation. SAS-SV, Smartphone Addiction Scale-Short Version; SDS, Zung's Self-Rating Depression Scale.

[a] P-value calculated using the independent-samples t-test; [b] P-value calculated using the Chi-square test.

baseline SA severity and depression severity at baseline (0.34, $P < 0.001$) and follow-up (0.23, $P < 0.001$). Again, although depression severity in the follow-up survey was predicted by baseline SA severity (path coefficient: 0.08; $P = 0.008$), the path coefficient was smaller than that of the predictive effect of the severity of baseline depression to the severity of follow-up depression (0.37; $P < 0.001$) and cross-sectional associations between SA and depression in the baseline and follow-up surveys, respectively (Figure 1 and Table 4).

3.5. Multi-group analysis by gender

Multi-group analyses by gender of the CLPM was conducted, and the models revealed satisfactory model fit [male group: $\chi 2/df = 15.08$ ($\chi 2 = 15.08$, $df = 1$, $P < 0.001$), CFI = 0.93, GFI = 0.99, and RMSEA = 0.16 (95% CI: 0.09, 0.23); female group: $\chi 2/df = 23.13$ ($\chi 2 = 23.13$, $df = 1$, $P < 0.001$), CFI =0.93, GFI =0.98, and RMSEA = 0.19 (95% CI: 0.13, 0.26)]. Among the male group, the relationship between SAS-SV and SDS scores was not significant in either direction. In contrast, among the female group, baseline depression severity predicted the SA severity in the follow-up survey (path coefficient: 0.15; $P < 0.001$), and also, baseline SA severity predicted depression severity in the follow-up survey (path coefficient: 0.10; $P = 0.015$) (Figure 2 and Table 4).

4. Discussion

In this study, we adopted a two-wave longitudinal design and constructed a cross-lagged panel model (CLPM) model to examine the bidirectional relationship between SA and depression among freshmen. This study showed that, (1) high rates of SA and depression exist in the freshman cohort; (2) both SA and depression rates among freshmen are highly stable during the first year of college, while this period is also a high prevalence of SA and depression among baseline normal freshmen; (3) SA was significantly associated with depression in cross-sectional analyses at both time points; (4) CLPM showed that SA and depression were bidirectionally associated and this relationship was significant in the female group but not in the male group.

The rate of SA among incoming freshmen was 32.0%; at the time of follow-up, at the beginning of the sophomore year, this rate increased to 52.5%. This indicates that college freshmen may use their smartphones more and have a higher risk of SA. Of these, a significant number (67.1%) of students with baseline SA were still addicted to their smartphones at 12 months. This finding is important because some researchers have expressed doubts about the stability of SA and similar conditions when debating the validity of SA as a disorder (34, 35). Also, close to half of the students (45.7%) with non-SA at baseline developed SA symptoms at follow-up. Actually, the rate of SA (36, 37) among teenagers has risen dramatically during the COVID-19 pandemic. The incidence of SA among Italian adolescents has also increased, from 26.1% before the pandemic to 46.7% during the pandemic (36). Fund et al. (37) investigated a population of elementary school students in China and found that SA was significantly higher during the outbreak. Olvera et al. (38) indicated that TikTok saw a phenomenal increase in popularity during the COVID-19 pandemic, while Marengo et al. (39) found that TikTok was the most addictive application during this period. This also proves that it is important to guide and correct smartphone use behavior during the pandemic for college students, especially freshmen.

SA was more prevalent among males than females at baseline and follow-up surveys. It is inconsistent with previous studies, which

TABLE 2 The detection rates and predictors for smartphone addiction and depression in the baseline among respondents who responded to both surveys.

	Smartphone addiction					Depression				
	N	Prevalence rates (95%CI[a])	$\chi^{2\ b}$ (*P* value)	Adjusted OR[c] (95%CI)	*P* value	*N*	Prevalence rates (95%CI[a])	$\chi^{2\ b}$ (*P* value)	Adjusted OR[d] (95%CI)	*P* value
Total (*n* = 1,186)	380	32.0 (29.4, 34.7)				127	10.7 (8.9, 12.5)			
Gender			22.00 (<0.001)					4.76 (0.03)		
Male (*n* = 566)	219	38.7 (34.7, 42.7)		1.93 (1.49, 2.50)		49	8.7 (6.3, 11.0)		1	
Female (*n* = 620)	161	26.0 (22.5, 29.4)		1	<0.001	78	12.6 (10.0, 15.2)		1.73 (1.16, 2.56)	0.01
Parental education level			1.80 (0.18)					1.88 (0.17)		
Below bachelor's degree (*n* = 924)	305	33.0 (30.0, 36.0)		1		105	11.4 (9.3, 13.4)		1	
Bachelor's degree or above (*n* = 262)	75	28.6 (23.1, 34.1)		0.90 (0.60, 1.35)	0.60	22	8.4 (5.0, 11.8)		1.10 (0.58, 2.09)	0.77
Maternal education level			2.26 (0.13)					2.76 (0.10)		
Below bachelor's degree (*n* = 1,016)	334	32.9 (30.0, 35.8)		1		115	11.3 (9.4, 13.3)		1	
Bachelor's degree or above (*n* = 170)	46	27.1 (20.3, 33.8)		0.94 (0.59, 1.50)	0.79	12	7.1 (3.2, 10.9)		0.63 (0.29, 1.37)	0.25
Body-Mass Index			0.86 (0.84)					4.46 (0.22)		
Wasting (*n* = 207)	62	30.0 (23.7, 36.2)		1		23	11.1 (6.8, 15.4)		1	
Normal (*n* = 720)	235	32.6 (29.2, 36.1)		1.09 (0.77, 1.54)	0.64	84	11.7 (9.3, 14.0)		1.07 (0.65, 1.76)	0.79
Overweight (*n* = 187)	58	31.0 (24.3, 37.7)		0.93 (0.60, 1.45)	0.75	17	9.1 (4.9, 13.2)		0.91 (0.46, 1.79)	0.78
Obese (*n* = 72)	25	34.7 (23.5, 46.0)		1.12 (0.62, 2.02)	0.70	3	4.2 (0.6, 8.9)		0.39 (0.11, 1.37)	0.14
Smartphone addiction								28.03 (<0.001)		
No (*n* = 806)						60	7.4 (5.6, 9.3)		1	
Yes (*n* = 380)						67	17.6 (13.8, 21.5)		2.89 (1.97, 4.24)	<0.001
Depression			28.03 (<0.001)							
No (*n* = 1,059)	313	29.6 (26.8, 32.3)		1						
Yes (*n* = 127)	67	52.8 (44.0, 61.6)		2.88 (1.97, 4.23)	<0.001					

[a] 95%CI: 95% confidence interval.

[b] χ2- Chi-square.

[c] Adjusted OR: adjusted odds ratio based on Binary Logistic Regression (Enter) using smartphone addiction in the baseline survey as a dependent variable and gender, parental education level, maternal education level, Body-Mass Index, and depression in the baseline survey as independent variables.

[d] Adjusted OR: adjusted odds ratio based on Binary Logistic Regression (Enter) using depression in the baseline survey as the dependent variable and gender, parental education level, maternal education level, Body-Mass Index, and smartphone addiction in the baseline survey as independent variables.

TABLE 3 The detection rates and predictors for smartphone addiction and depression in the following among respondents who responded to both surveys.

	Smartphone addiction					Depression				
	N	Prevalence rates (95%CI[a])	χ2[b] (*P* value)	Adjusted OR[c] (95%CI)	*P* value	N	Prevalence rates (95%CI[a])	χ2[b] (*P* value)	Adjusted OR[d] (95%CI)	*P* value
Total (*n* = 1,186)	623	52.5 (49.7, 55.4)				335	28.2 (25.7, 30.8)			
Gender			5.25 (0.02)					12.27 (<0.001)		
Male (*n* = 566)	317	56.0 (51.9, 60.1)		1.30 (1.03, 1.66)		187	33.0 (29.2, 36.9)		1.56 (1.20, 2.03)	
Female (*n* = 620)	306	49.4 (45.4, 53.3)		1	0.03	148	23.9 (20.5, 27.2)		1	<0.001
Parental education level			0.86 (0.35)					0.87 (0.35)		
Below bachelor's degree (*n* = 924)	492	53.2 (50.0, 56.5)		1		267	28.9 (26.0, 31.8)		1	
Bachelor's degree or above (*n* = 262)	131	50.0 (43.9, 56.1)		1.01 (0.69, 1.46)	0.97	68	26.0 (20.6, 31.3)		1.14 (0.74, 1.74)	0.56
Maternal education level			1.09 (0.30)					1.23 (0.27)		
Below bachelor's degree (*n* = 1,016)	540	53.1 (50.1, 56.2)		1		293	28.8 (26.0, 31.6)		1	
Bachelor's degree or above (*n* = 170)	83	48.8 (41.2, 56.4)		0.94 (0.62, 1.43)	0.77	42	24.7 (18.2, 31.3)		0.97 (0.59, 1.58)	0.89
Body-Mass Index			4.04 (0.26)					2.55 (0.47)		
Wasting (*n* = 207)	101	48.8 (41.9, 55.7)		1		61	29.5 (23.2, 35.7)		1	
Normal (*n* = 720)	395	54.9 (51.2, 58.5)		1.28 (0.94, 1.76)	0.12	197	27.4 (24.1, 30.6)		0.86 (0.61, 1.22)	0.41
Overweight (*n* = 187)	91	48.7 (41.4, 55.9)		0.93 (0.62, 1.40)	0.72	60	32.1 (25.3, 38.8)		1.07 (0.69, 1.66)	0.78
Obese (*n* = 72)	36	50.0 (38.2, 61.8)		1.04 (0.60, 1.81)	0.88	17	23.6 (13.6, 33.7)		0.66 (0.35, 1.24)	0.20
Smartphone addiction at follow-up								16.06 (<0.001)		
No (*n* = 563)						128	22.7 (19.3, 26.2)		1	
Yes (*n* = 623)						207	33.2 (29.5, 36.9)		1.65 (1.27, 2.14)	<0.001
Depression at follow-up			16.06 (<0.001)							
No (*n* = 851)	416	48.9 (45.5, 52.2)		1						
Yes (*n* = 335)	207	61.8 (56.6, 67.0)		1.64 (1.26, 2.13)	<0.001					
Smartphone addiction at baseline										
No (*n* = 806)	368	45.7 (42.2, 49.1)								
Yes (*n* = 380)	255	67.1 (62.4, 71.9)								
Depression at baseline										
No (*n* = 1059)						258	24.4 (21.8, 27.0)			
Yes (*n* = 127)						77	60.6 (52.0, 69.2)			

[a] 95%CI: 95% confidence interval.

[b] χ2- Chi-square.

[c] Adjusted OR: adjusted odds ratio based on Binary Logistic Regression (Enter) using smartphone addiction in the follow-up survey as a dependent variable and gender, parental education level, maternal education level, Body-Mass Index, and depression in the follow-up survey as independent variables.

[d] Adjusted OR: adjusted odds ratio based on Binary Logistic Regression (Enter) using depression in the follow-up survey as the depe and gender, parental education level, maternal education level, Body-Mass Index, and smartphone addiction in the follow-up survey as independent variables.

suggested that females were significantly associated with a propensity for SA (34, 40, 41). We argued that such inconsistent findings might partially be attributed to the fact that the study population in this study was freshmen, that male students may be more proficient in using technology (42) and that there are some differences in the content of smartphone use between males and females (40, 43). Consistent with our results, a study conducted at an Indian medical school found that the SA rate reached 52.0% and was more prevalent in males than females (44). In addition, several other studies have found no significant gender differences in the prevalence of SA (45, 46). Further studies still need to unravel the inconsistent prevalence of SA in males and females.

As for depression, in our study, the prevalence of depression among freshmen was 10.7%, while one year later, this rate rose to 28.8%, and the new incidence during this period was 24.4%. On the one hand, this indicates that the prevalence of depression is high among Chinese adolescents. Duan et al. (13) indicated that the COVID-19 outbreak has had a significant psychosocial impact on Chinese adolescents and that high school graduates affected by the outbreak were significantly associated with depression. On the other hand, it points to a high prevalence of depression among freshmen. Ebert et al. (10) found that the incidence of major depressive disorder (MDD) within the first year of college was 6.9%, suggesting that the first year in college constitutes a risk period for the onset of MDD. Considering the context of life transition, freshmen are in an unfamiliar transition period and are vulnerable to depression and other mental health problems (47). During this period, students face a change in their living environment, a change in their learning methods, and a change from dependence to autonomy, and if they cannot adapt to this collective life in time, they can easily fall into emotional distress. As to gender, this is a controverted matter, with some studies suggesting that females are more likely to suffer from depression (48, 49), while in contrast, other researchers insist that males are more likely to experience depression than females (50). Our study found that the prevalence of depression was higher among freshmen females, and after 1 year, it was higher among males. A plausible explanation is that gender may have a significant effect only at the stage from moderate to severe depression (49), and the present study did not classify the severity level of depression. Therefore, the problem of depression among college students continues to require close attention and effort.

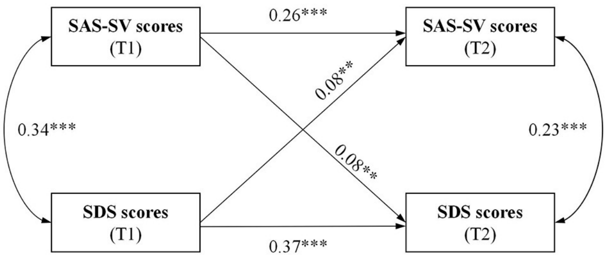

FIGURE 1
CLPM of SAS-SV and SDS scores at baseline (T1) and follow-up (T2, over 12 months) with standardized path coefficients. $^{**}P < 0.01$; $^{***}P < 0.001$; T1 = assessed at baseline, T2 = assessed at follow-up. SAS-SV, Smartphone Addiction Scale-Short Version; SDS, Zung's Self-Rating Depression Scale; Single-headed arrows denote regressions, double-headed arrows denote correlations.

The CLPM results showed that the overall association between SA and depression was bidirectional; however, multi-group analysis by gender revealed that this bidirectional association persisted in the female group, whereas in the male group, the association was not significant in either direction. Among the female group, the cross-lagged effect coefficient from depression to SA was relatively larger than the reverse effect, suggesting that depressive symptoms may worsen SA to a greater extent. This echoes the previous findings, which suggested that SA or similar conditions can be caused by depressive symptoms (14, 51). Studies have found that depressed individuals derive less pleasure from social interactions and have increased sensitivity to social rejection (52, 53), but have a tendency to use social media more frequently (54). Frequent smartphone use as an avoidance-coping strategy appears to present them with a viable alternative to uncomfortable face-to-face contact in social situations. Furthermore, Elhai et al. (55) argued that smartphone use has also been proposed as a coping process for depressed mood (boredom tendencies, mood dysregulation, and pain intolerance). This avoidance-coping tends to foster reliance on online activities (52, 56). In the context of excessive smartphone use, not only may irrational beliefs or perceptions arise (feelings of inferiority, insecurity and self-esteem fluctuations) (57), but also social comparisons, a phenomenon of "emotional contagion" (58), leading to negative emotions such as depression and anxiety (59). Studies have also found that SA can lead to sleep disorders and delayed sleep, which are predictors of depression (60). Thus, SA and depression may form a vicious circle. Therefore, preventive control measures targeting depression should focus on smartphone use, while interventions targeting SA should incorporate a psychological component and appropriately increase attention to the female group.

TABLE 4 Summary of the parameters for the whole sample, male and female of the CLPM.

	All (*n* = 1,186)				Male (*n* = 566)				Female (*n* = 620)			
	B	***SE***	***β***	***P***	**B**	***SE***	***β***	***P***	**B**	***SE***	***β***	***P***
SAS-SV-T1 to SAS-SV-T2	0.32	0.036	0.26	<0.001	0.30	0.057	0.23	<0.001	0.35	0.045	0.31	<0.001
SAS-SV-T1 to SDS-T2	0.10	0.039	0.08	0.008	0.07	0.058	0.05	0.222	0.12	0.050	0.10	0.015
SDS-T1 to SAS-SV-T2	0.09	0.032	0.08	0.008	−0.01	0.053	−0.01	0.911	0.15	0.039	0.15	<0.001
SDS-T1 to SDS-T2	0.45	0.035	0.37	<0.001	0.50	0.054	0.37	<0.001	0.44	0.044	0.39	<0.001

SE, Standard error; T1 = assessed at baseline, T2 = assessed at follow-up. SAS-SV, Smartphone Addiction Scale-Short Version; SDS, Zung's Self-Rating Depression Scale. Standardized coefficients and standardized confidence intervals are shown.

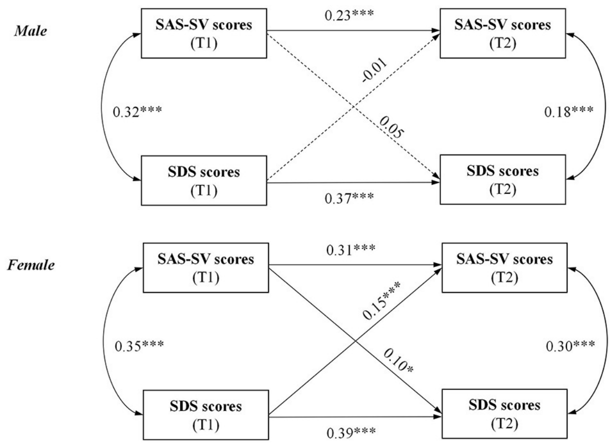

FIGURE 2
Path diagram of the CLPM by gender. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; T1, assessed at baseline; T2, assessed at follow-up. SAS-SV, Smartphone Addiction Scale-Short Version; SDS, Zung's Self-Rating Depression Scale; Single-headed arrows denote regressions, double-headed arrows denote correlations; Solid lines present statistically significant associations and dashed lines present nonsignificant associations.

This finding of gender differences is inconsistent with the studies of Park et al. (61), who observed significant changes in the longitudinal relationship between SA and depression among Korean adolescents across time, but no gender differences were found in the strength of these relationships. Possible mechanisms lie in physiological differences between the sexes (e.g., genetic vulnerability) (62), differences in self-concept (63), and differences in stress perception (64) that result in different emotional responses and behavioral patterns. Compared to males, females are more likely to perceive stress, and self-distraction may be considered one of the effective coping mechanisms (64). Females are more likely to internalize their negative emotions, whereas males' resort to externalizing behaviors, such as aggression and substance use (65, 66). Tang et al. (67) found that although female freshmen received more social support and had better help-seeking skills than males, females exhibited higher rates of depression. One possible explanation may be that females are perceived as more frequently, emotionally, and relatively exposed to stressful situations compared to males (68). Another reason could be that females are more likely to seek support through mobile social software, and their dependence on smartphones leads to a great sense of loss when they face real life (69). The findings suggest that researchers and practitioners have to take gender differences in understanding the bidirectional influences between SA and depression.

The current study has several limitations. Firstly, we recruited only freshmen from the same university to ensure consistent learning patterns. It may be possible to obtain richer results if college students in different years could be surveyed simultaneously at the same time. Therefore, further studies with a larger sample of representative Chinese college students are necessary to confirm our present findings. Secondly, only two-time points were assessed in this study. More waves and longer years of follow-up are warranted to understand better the stability of and changes in SA and depression. Third, the results of the validated factor analysis of SDS in this study were unsatisfactory, which we thought might be related to the fact that the study subjects were medical students with some medical background and were relatively familiar with the SDS scale. Attention should be paid to the selection of scales in future studies of depressive tendencies in college students, especially medical students. Fourth, other relevant questions, such as type of smartphone use, objective smartphone use time, and frequency of use, were not investigated, so we could not provide explicit confirmation of addicts' use patterns to support the discussion around this topic.

5. Conclusions

In conclusion, the study found that both smartphone addiction (SA) and depression were prevalent among freshmen and that there was a bidirectional predictive association between SA and depression, especially and only in the female group. Therefore, we should strengthen early intervention for behaviors related to SA among freshmen while focusing on related mental health issues.

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 Anhui Medical University (No. 20190495). 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

KZ: conceptualization, formal analysis, writing–original draft, writing–review, and editing. HG: methodology, investigation, and data curation. TW: investigation, data curation, and formal analysis. JZ, GY, JR, XZ, and HY: investigation and data curation. XL, ZZhu, JD, HS, and GJ: investigation. JH, YS, and PS: validation and project administration. ZZha: validation and funding acquisition. 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

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1083856/full#supplementary-material

References

1. De-Sola Gutiérrez J, Rodríguez de Fonseca F, Rubio G. Cell-phone addiction: a review. *Front Psychiatry.* (2016) 7:175. doi: 10.3389/fpsyt.2016.00175

2. Zhong Y, Ma H, Liang YF, Liao CJ, Zhang CC, Jiang WJ. Prevalence of smartphone addiction among Asian medical students: a meta-analysis of multinational observational studies. *Int J Soc Psychiatry.* (2022) 68:1171–83. doi: 10.1177/00207640221089535

3. Meng SQ, Cheng JL, Li YY, Yang XQ, Zheng JW, Chang XW, et al. Global prevalence of digital addiction in general population: a systematic review and meta-analysis. *Clin Psychol Rev.* (2022) 92:102128. doi: 10.1016/j.cpr.2022.102128

4. Lapierre MA, Zhao P, Custer BE. Short-term longitudinal relationships between smartphone use/dependency and psychological well-being among late adolescents. *J Adolesc Health.* (2019) 65:607–12. doi: 10.1016/j.jadohealth.2019.06.001

5. Ratan ZA, Parrish AM, Zaman SB, Alotaibi MS, Hosseinzadeh H. Smartphone Addiction and Associated Health Outcomes in Adult Populations: a Systematic Review. *Int J Environ Res Public Health.* (2021) 18:12257. doi: 10.3390/ijerph182212257

6. Fineberg NA, Menchón JM, Hall N, Dell'Osso B, Brand M, Potenza MN, et al. Advances in problematic usage of the internet research - A narrative review by experts from the European network for problematic usage of the internet. *Compr Psychiatry.* (2022) 118:152346. doi: 10.1016/j.comppsych.2022.152346

7. Weinstein A, Siste K. Editorial: excessive and problematic smartphone usage. *Front Psychiatry.* (2022) 13:972613. doi: 10.3389/fpsyt.2022.972613

8. Shorey S, Ng ED, Wong CHJ. Global prevalence of depression and elevated depressive symptoms among adolescents: a systematic review and meta-analysis. *Br J Clin Psychol.* (2022) 61:287–305. doi: 10.1111/bjc.12333

9. Zhang X, Yang H, Zhang J, Yang M, Yuan N, Liu J. Prevalence of and risk factors for depressive and anxiety symptoms in a large sample of Chinese adolescents in the post-COVID-19 era. *Child Adolesc Psychiatry Ment Health.* (2021) 15:80. doi: 10.1186/s13034-021-00429-8

10. Ebert DD, Buntrock C, Mortier P, Auerbach R, Weisel KK, Kessler RC, et al. Prediction of major depressive disorder onset in college students. *Depress Anxiety.* (2019) 36:294–304. doi: 10.1002/da.22867

11. Liu H, Zhou Z, Zhu E, Huang L, Zhang M. Smartphone addiction and its associated factors among freshmen medical students in China: a cross-sectional study. *BMC Psychiatry.* (2022) 22:308. doi: 10.1186/s12888-022-03957-5

12. Ng KC, Wu LH, Lam HY, Lam LK, Nip PY, Ng CM, et al. The relationships between mobile phone use and depressive symptoms, bodily pain, and daytime sleepiness in Hong Kong secondary school students. *Addict Behav.* (2020) 101:105975. doi: 10.1016/j.addbeh.2019.04.033

13. Duan L, Shao X, Wang Y, Huang Y, Miao J, Yang X, et al. An investigation of mental health status of children and adolescents in china during the outbreak of COVID-19. *J Affect Disord.* (2020) 275:112–8. doi: 10.1016/j.jad.2020.06.029

14. Pera A. The psychology of addictive smartphone behavior in young adults: problematic use, social anxiety, depressive stress. *Front Psychiatry.* (2020) 11:573473. doi: 10.3389/fpsyt.2020.573473

15. Matar Boumosleh J, Jaalouk D. Depression, anxiety, and smartphone addiction in university students- a cross sectional study. *PLoS ONE.* (2017) 12:e0182239. doi: 10.1371/journal.pone.0182239

16. Li Y, Li G, Liu L, Wu H. Correlations between mobile phone addiction and anxiety, depression, impulsivity, and poor sleep quality among college students: a systematic review and meta-analysis. *J Behav Addict.* (2020) 9:551–71. doi: 10.1556/2006.2020.00057

17. Kardefelt-Winther D. A conceptual and methodological critique of internet addiction research: towards a model of compensatory internet use. *Comput Human Behav.* (2014) 31:351–4. doi: 10.1016/j.chb.2013.10.059

18. Vally Z. Anger and worry are related to problematic smartphone use: a cross-sectional examination of novel psychopathological constructs in a college-aged sample in the United Arab Emirates. *Heliyon.* (2022) 8:e10917. doi: 10.1016/j.heliyon.2022.e10917

19. Long J, Liu TQ, Liao YH, Qi C, He HY, Chen SB, et al. Prevalence and correlates of problematic smartphone use in a large random sample of Chinese undergraduates. *BMC Psychiatry.* (2016) 16:408. doi: 10.1186/s12888-016-1083-3

20. Feinstein BA, et al. Negative social comparison on facebook and depressive symptoms: rumination as a mechanism. *Psychol Pop Media Cult.* (2013) 2:161–70. doi: 10.1037/a0033111

21. Boers E, Afzali MH, Newton N, Conrod P. Association of screen time and depression in adolescence. *JAMA Pediatr.* (2019) 173:853–9. doi: 10.1001/jamapediatrics.2019.1759

22. Samra A, Warburton WA, Collins AM. Social comparisons: a potential mechanism linking problematic social media use with depression. *J Behav Addict.* (2022) 11:607–14. doi: 10.1556/2006.2022.00023

23. Crockett MA, Martínez V, Jiménez-Molina Á. Subthreshold depression in adolescence: Gender differences in prevalence, clinical features, and associated factors. *J Affect Disord.* (2020) 272:269–76. doi: 10.1016/j.jad.2020.03.111

24. Albursan IS, Qudah MFA, Al-Barashdi HS, Bakhiet SF, Darandari E, Al-Asqah SS, et al. Smartphone addiction among university students in light of the COVID-19 pandemic: prevalence, relationship to academic procrastination, quality of life, gender and educational stage. *Int J Environ Res Public Health.* (2022) 19:10439. doi: 10.3390/ijerph191610439

25. Zhu X, Shek DTL, Chu CKM. Internet addiction and emotional and behavioral maladjustment in mainland chinese adolescents: cross-lagged panel analyses. *Front Psychol.* (2021) 12:781036. doi: 10.3389/fpsyg.2021.781036

26. Zhou H, Dang L, Lam LW, Zhang MX, Wu AMS. A cross-lagged panel model for testing the bidirectional relationship between depression and smartphone addiction and the influences of maladaptive metacognition on them in Chinese adolescents. *Addict Behav.* (2021) 120:106978. doi: 10.1016/j.addbeh.2021.106978

27. Chen IH, Pakpour AH, Leung H, Potenza MN, Su JA, Lin CY, et al. Comparing generalized and specific problematic smartphone/internet use: longitudinal relationships between smartphone application-based addiction and social media addiction and psychological distress. *J Behav Addict.* (2020) 9:410–9. doi: 10.1556/2006.2020.00023

28. Kwon M, Kim DJ, Cho H, Yang S. The smartphone addiction scale: development and validation of a short version for adolescents. *PloS ONE.* (2013) 8:e83558. doi: 10.1371/journal.pone.0083558

29. Mingqiang X, Zirong W, Ben M. Reliability and validity of chinese version of the smartphone addiction scale in adolescents (In Chinese). *Chin J Clin Psychol.* (2019) 27:959–64. doi: 10.16128/j.cnki.1005-3611.2019.05.022

30. Zung WW. A self-rating depression scale. *Arch Gen Psychiatry.* (1965) 12:63–70. doi: 10.1001/archpsyc.1965.01720310065008

31. Dunstan DA, Scott N, Todd AK. Screening for anxiety and depression: reassessing the utility of the Zung scales. *BMC Psychiatry.* (2017) 17:329. doi: 10.1186/s12888-017-1489-6

32. Shu L. [Self-rating depression scale (SDS)]. In: Wang X, Wang X, Ma H, editors. *Rating Scales for Mental Health.* Beijing: Chinese Mental Health Journal Publisher. (1999). p. 194–6.

33. Gong J, Chan RCK. Early maladaptive schemas as mediators between childhood maltreatment and later psychological distress among Chinese college students. *Psychiatry Res.* (2018) 259:493–500. doi: 10.1016/j.psychres.2017.11.019

34. Yu S, Sussman S. Does smartphone addiction fall on a continuum of addictive behaviors? *Int J Environ Res Public Health.* (2020) 17:422. doi: 10.3390/ijerph17020422

35. Panova T, Carbonell X. Is smartphone addiction really an addiction? *J Behav Addict.* (2018) 7:252–9. doi: 10.1556/2006.7.2018.49

36. Serra G, Scalzo LL, Giuffrè M, Ferrara P, Corsello G. Smartphone use and addiction during the coronavirus disease 2019 (COVID-19) pandemic: cohort study on 184 Italian children and adolescents. *Ital J Pediatr.* (2021) 47:150. doi: 10.1186/s13052-021-01102-8

37. Fung XCC, Siu AMH, Potenza MN, O'Brien KS, Latner JD, Chen CY, et al. Problematic use of internet-related activities and perceived weight stigma in schoolchildren: a longitudinal study across different epidemic periods of COVID-19 in China. *Front Psychiatry.* (2021) 12:675839. doi: 10.3389/fpsyt.2021.675839

38. Olvera C, Stebbins GT, Goetz CG, Kompoliti K. TikTok tics: a pandemic within a pandemic. *Mov Disord Clin Pract.* (2021) 8:1200–5. doi: 10.1002/mdc3.13316

39. Marengo D, Fabris MA, Longobardi C, Settanni M. Smartphone and social media use contributed to individual tendencies towards social media addiction in Italian adolescents during the COVID-19 pandemic. *Addict Behav.* (2022) 126:107204. doi: 10.1016/j.addbeh.2021.107204

40. Carbonell X, Chamarro A, Oberst U, Rodrigo B, Prades M. Problematic use of the internet and smartphones in University Students: 2006-2017. *Int J Environ Res Public Health.* (2018) 15:475. doi: 10.3390/ijerph15030475

41. Garrote GPd, Rubio L, Gómez BM, Buedo-Guirado C. Smartphone abuse amongst adolescents: the role of impulsivity and sensation seeking. *Front Psychol.* (2021) 12:746626. doi: 10.3389/fpsyg.2021.746626

42. Wu J, Siu ACK. Problematic mobile phone use by Hong Kong adolescents. *Front Psychol.* (2020) 11:551804. doi: 10.3389/fpsyg.2020.551804

43. Park J, Jeong JE, Rho MJ. Predictors of habitual and addictive smartphone behavior in problematic smartphone use. *Psychiatry Investig.* (2021) 18:118–25. doi: 10.30773/pi.2020.0288

44. Dhamija S, Shailaja B, Chaudhari B, Chaudhury S, Saldanha D. Prevalence of smartphone addiction and its relation with sleep disturbance and low self-esteem among medical college students. *Ind Psychiatry J.* (2021) 30:S189–94. doi: 10.4103/0972-6748.328813

45. Chen B, Liu F, Ding S, Ying X, Wang L, Wen Y. Gender differences in factors associated with smartphone addiction: a cross-sectional study among medical college students. *BMC Psychiatry.* (2017) 17:341. doi: 10.1186/s12888-017-1503-z

46. Okasha T, Saad A, Ibrahim I, Elhabiby M, Khalil S, Morsy M. Prevalence of smartphone addiction and its correlates in a sample of Egyptian university students. *Int J Soc Psychiatry.* (2022) 68:1580–8. doi: 10.1177/00207640211042917

47. Chan V, Moore J, Derenne J, Fuchs DC. Transitional age youth and college mental health. *Child Adolesc Psychiatr Clin N Am.* (2019) 28:363–75. doi: 10.1016/j.chc.2019.02.008

48. Liu Y, Zhang N, Bao G, Huang Y, Ji B, Wu Y, et al. Predictors of depressive symptoms in college students: a systematic review and meta-analysis of cohort studies. *J Affect Disord.* (2019) 244:196–208. doi: 10.1016/j.jad.2018.10.084

49. Sun XJ, Niu GF, You ZQ, Zhou ZK, Tang Y. Gender, negative life events and coping on different stages of depression severity: a cross-sectional study among Chinese university students. *J Affect Disord.* (2017) 209:177–81. doi: 10.1016/j.jad.2016.11.025

50. Song Y, Liu Z, Chen H, Guo Q, Huang Y. Incidence and risk factors of depressive symptoms in Chinese college students. *Neuropsychiatr Dis Treat.* (2020) 16:2449–57. doi: 10.2147/NDT.S264775

51. West R, Ash C, Dapore A, Kirby B, Malley K, Zhu S. Problematic smartphone use: The role of reward processing, depressive symptoms and self-control. *Addict Behav.* (2021) 122:107015. doi: 10.1016/j.addbeh.2021.107015

52. Haskell AM, Britton PC, Servatius RJ. Toward an assessment of escape/avoidance coping in depression. *Behav Brain Res.* (2020) 381:112363. doi: 10.1016/j.bbr.2019.112363

53. Yuan Y, Jiang S, Yan S, Chen L, Zhang M, Zhang J, et al. The relationship between depression and social avoidance of college students: a moderated mediation model. *J Affect Disord.* (2022) 300:249–54. doi: 10.1016/j.jad.2021.12.119

54. Jeri-Yabar A, Sanchez-Carbonel A, Tito K. Ramirez-delCastillo J, Torres-Alcantara A, Denegri D, et al. Association between social media use (Twitter, Instagram, Facebook) and depressive symptoms: Are Twitter users at higher risk? *Int J Soc Psychiatry.* (2019) 65:14–9. doi: 10.1177/0020764018814270

55. Elhai JD, Yang H, Montag C. Cognitive- and emotion-related dysfunctional coping processes: transdiagnostic mechanisms explaining depression and anxiety's relations with problematic smartphone use. *Curr Addict Rep.* (2019) 6:410–7. doi: 10.1007/s40429-019-00260-4

56. Kang Y, Liu S, Yang L, Xu B, Lin L, Xie L, et al. Testing the bidirectional associations of mobile phone addiction behaviors with mental distress, sleep disturbances, and sleep patterns: a one-year prospective study among Chinese college students. *Front Psychiatry.* (2020) 11:634. doi: 10.3389/fpsyt.2020.00634

57. Jun S. Longitudinal influences of depressive moods on problematic mobile phone use and negative school outcomes among Korean adolescents. *Sch Psychol Int.* (2019) 40:294–308. doi: 10.1177/0143034319830452

58. Coviello L, Sohn Y, Kramer ADI, Marlow C, Franceschetti M, Christakis NA, et al. Detecting emotional contagion in massive social networks. *PLoS ONE.* (2014) 9:e90315. doi: 10.1371/journal.pone.0090315

59. Pantic I, Damjanovic A, Todorovic J, Topalovic D, Bojovic-Jovic D, Ristic S, et al. Association between online social networking and depression in high school students: behavioral physiology viewpoint. *Psychiatr Danub.* (2012) 24:90–3.

60. Liu M, Lu C. Mobile phone addiction and depressive symptoms among Chinese University students: the mediating role of sleep disturbances and the moderating role of gender. *Front Public Health.* (2022) 10:965135. doi: 10.3389/fpubh.2022.965135

61. Park SY, et al. Long-term symptoms of mobile phone use on mobile phone addiction and depression among Korean adolescents. *Int J Environ Res Public Health.* (2019) 16:3584. doi: 10.3390/ijerph16193584

62. Liu XQ, Guo YX, Zhang WJ, Gao WJ. Influencing factors, prediction and prevention of depression in college students: a literature review. *World J Psychiatry.* (2022) 12:860–73. doi: 10.5498/wjp.v12.i7.860

63. Li J, Liu Y, Song J. The relationship between gender self-stereotyping and life satisfaction: the mediation role of relational self-esteem and personal self-esteem. *Front Psychol.* (2021) 12:769459. doi: 10.3389/fpsyg.2021.769459

64. Graves BS, Hall ME, Dias-Karch C, Haischer MH, Apter C. Gender differences in perceived stress and coping among college students. *PLoS ONE.* (2021) 16:e0255634. doi: 10.1371/journal.pone.0255634

65. Rollero C, De Piccoli N. Self-objectification and personal values. An exploratory study. *Front Psychol.* (2017) 8:1055. doi: 10.3389/fpsyg.2017.01055

66. Shulla RM, Toomey RB. Sex differences in behavioral and psychological expression of grief during adolescence: a meta-analysis. *J Adolesc.* (2018) 65:219–27. doi: 10.1016/j.adolescence.2018.04.001

67. Tang WDai Q. Depressive symptoms among first-year Chinese undergraduates: The roles of socio-demographics, coping style, and social support. *Psychiatry Res.* (2018) 270:89–96. doi: 10.1016/j.psychres.2018.09.027

68. Wu X, Tao S, Zhang Y, Li S, Ma L, Yu Y, et al. Geographic distribution of mental health problems among Chinese college students during the COVID-19 pandemic: nationwide, web-based survey study. *J Med Internet Res.* (2021) 23:e23126. doi: 10.2196/23126

69. Liang L, Zhou D, Yuan C, Shao A, and Bian Y. Gender differences in the relationship between internet addiction and depression: A cross-lagged study in Chinese adolescents. *Comput Hum Behav.* (2016) 63:463–70. doi: 10.1016/j.chb.2016.04.043

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Internet use and rural-urban mental health inequalities: Evidence from China

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Introduction: In the context of the new digital era, clarifying the relationship between Internet use and urban and rural residents' mental health is of important value for reducing rural-urban health inequalities. This paper aims to study the association between Internet use and rural-urban mental health inequalities.

Methods: Based on the data of the China Family Panel Studies (CFPS) in 2020, we firstly examined the existence and specific manifestation of mental health inequalities between urban and rural residents. Secondly, we examined the mediating effect of Internet use by the Bootstrap mediating effect measure. Finally, we verified the robustness of the mediating effect.

Results: There are significant mental health inequalities between urban and rural residents, and urban residents have better mental health than rural residents ($p < 0.01$). In addition, the test results for the mediating effect of Internet use on mental health inequalities between urban and rural residents were significant ($p < 0.01$), with a direct effect of -0.028 ($p < 0.01$) and an indirect effect of -0.49 ($p < 0.01$), and this result remained significant in the robustness test.

Discussion: In such a new age of the Internet, mental health inequalities between urban and rural residents objectively did exist, and the use of the internet played a positive mediation effect on the formation of mental health inequalities between urban and rural areas.

KEYWORDS

urban-rural differences, Internet use, mental health status, mental health inequalities, China

1. Introduction

In recent years, the Internet is embedded in social life, which is like a double-edged sword. On the one hand, online fraud, online pornography, online violence, and other functions endanger people's lives; On the other hand, online medical, virtual social and other Internet features can facilitate the healthy life of residents. Currently, although the Internet has been promoted nationwide in China, Internet users in China are still mainly urban residents, with relatively low Internet penetration in rural areas. There is a significant difference in the number of Internet users between urban and rural areas. According to China Internet Network Information Center (CNNIC), as of the end of March 2020, the total number of Internet users reached 904 million, of which 255 million were in rural areas and the Internet penetration rate was 46.2%. In contrast, 649 million were in urban areas and the Internet penetration rate was as high as 76.5%, with a significant gap of 30.3% between the two.

At the same time, Chinese society has long been characterized by health inequalities between urban and rural residents (1–3), especially in mental health (4, 5). A meta-analysis showed that the prevalence of depressive symptoms was nearly 10% higher in rural areas than in urban areas (6). In addition, several cross-sectional studies have shown that there is an urban-rural gap in mental health, especially among older adults and women (7, 8).

Under such background, we cannot help but think that, since there are differences between urban and rural areas in both internet use and mental health, do urban-rural differences affect the mental health inequalities of the population through Internet use? We focused on urban-rural differences because the internet coverage could be different in urban and rural areas. Firstly, due to the economic factors, richer towns/villages may have good internet facilities compared to those in poorer towns/villages (9, 10). Secondly, many of the younger generations living in urban areas are probably using the Internet. But older people in rural areas may be mostly less likely to be online use (11, 12).

A potential theoretical framework for the impact of Internet use on rural-urban mental health inequalities is shown in Figure 1. Differences in Internet use between urban and rural residents may affect rural-urban mental health inequalities in two ways. Firstly, Internet users generally have more opportunities for social engagement, social activities, and recreation (13, 14), thus providing depressed and lonely individuals with more opportunities for interpersonal and emotional communication, which is beneficial to mental health. Secondly, the use of the Internet can provide healthcare services through telemedicine (15) and facilitates the exchange of medical knowledge (16), thereby treating diseases more conveniently.

There have been studies with samples from developed countries showing that Internet use can cause urban-rural health inequalities (16), but these studies focus on inequalities between urban-rural physical health and ignore inequalities in mental health. In addition, these findings from developed countries may not apply to developing countries. Because developed countries have well-established healthcare systems and high urbanization rates, while rural patients in developing countries do not have access to the same healthcare resources. Therefore, there is a need to explore this issue separately in developing countries. China, as the largest developing country in the world, provides a good sample for exploring this issue. In China, although there have been numerous studies (17–22) demonstrating the role of mediating variables between urban and rural health inequalities such as medical accessibility (19) and socioeconomic status (20, 21), the mediating mechanism of the internet use has not received much attention.

Therefore, based on the above research background, we attempt to choose the latest released China Family Panel Studies (CFPS) data in China in 2020 to study the following issues: first, in the context of the new digital era, we demonstrate the objective existence of health inequalities between urban and rural residents in China and their specific manifestations in mental health. Second, using the world's largest developing country as a sample, we examine the mediating effects of Internet use in rural-urban health inequalities, so as to provide experiences for developing countries in eliminating rural-urban health inequalities.

2. Materials and methods

2.1. Data sources

The data used in this study are from the newly released 2020 China Family Panel Studies (CFPS) individual database. CFPS data is a nationally representative longitudinal study of Chinese communities, families, and individuals. Since 2010, CFPS data has been surveyed every 2 years, covering 25 provinces/regions or their administrative levels (i.e., municipalities and autonomous regions) out of 31 provinces/regions in China (23). For the CFPS in 2010, the multi-stage probability distribution was used to stratify the samples, and five provinces/regions (Gansu, Guangdong, Henan, Liaoning, and Shanghai) were selected for preliminary oversampling (1,600 families in each province/region, or 8,000 families in total) to obtain regional comparison, and another 8,000 families were weighted from other provinces/regions, making the entire CFPS sample nationally representative. CFPS has been approved by the Biomedical Ethics Review Committee of Peking University (ID: IRB00001052-14010). We chose CFPS as the data source for this study because of its broader research agenda, wider population coverage, and its national representation. For the original sample of 28,590, we removed samples ($N = 4{,}065$) with the following five conditions in the selected variables: unable to judge, missing, not applicable, refused to answer, and don't know, thus deriving the final sample size of 20,536.

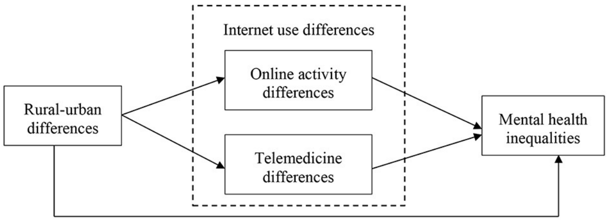

FIGURE 1
Theoretical framework of internet use and rural-urban mental health inequalities.

2.2. Measures

2.2.1. Dependent variable: Mental health

Depression is a commonly used variable to represent mental health (24–26). In this study, we also used depressive symptoms to measure mental health and used the CES-D8 scale to assess the severity and frequency of certain feelings and behaviors. Respondents were asked how often they felt unable to move forward in life, sad, happy, lonely, happy, poor sleep, hard to do things, and depressed. The scores for these items range from 1 (no time) to 4 (all or almost all of the time). We add the eight items together to develop a mental health index. The higher the score, the unhealthier the individual's psychology is.

In addition, we conducted robustness tests using subjective wellbeing. In psychology, the concepts of happiness, wellbeing, and mental health are often used as synonyms (27). The World Health Organization defines mental health as a state of well-being in which individuals are able to reach their potential, cope with the stresses of life, work productively, and contribute to society (28). Therefore, it is increasingly recognized that both mental health (e.g., depression) and wellbeing should be considered when measuring mental health (29). Mental health cannot be separated from subjective wellbeing, which is a positive aspect of mental health (30). Hence, subjective wellbeing was used for robustness testing in this study. We used the question "How happy do you think you are" from the CFPS to measure subjective wellbeing.

2.2.2. Core independent variable: Household registration status

Based on China's household registration system, we have divided people into urban and rural residents. We define "rural" as the respondents who report that they currently have agricultural household registration and "urban" as those who report that they have non-agricultural household registration or urban resident household registration (31). The household registration status is assigned a value of 1 if the respondent is an urban resident, and 0 if the respondent is a rural resident.

2.2.3. Mediating variable: Internet use

In this paper, Internet use refers to the behavior of people who can use Internet technology for learning, socializing, and entertainment through modern information and communication technology such as cell phones and computers. The variable "whether or not to access the Internet by computer" was generated by the questionnaire, and the answer "yes" was assigned a value of 1, and the answer "no" was assigned a value of 0.

2.2.4. Control variables

The control variables include age, gender, marriage, education, income level, and work status. Among them, age, gender, and marriage can be categorized as natural attributes affecting health status, while education, income level, and work status are mainly indicators of socioeconomic status. Previous studies have shown that as age increases, the health status of the population becomes worse (32, 33); gender is related to age (34, 35); the lower level of education, the worse health status (36, 37); marital status also affects the emotional health of the population (38, 39); the higher income, the better health (40); work status has also been found to be strongly associated with health (41). Therefore, in this paper, the above variables that may affect health were controlled to exclude relevant interference. In terms of assignment, age is a continuous variable, ranging from 9 to 104 years old; gender is assigned as 1 for male and 0 for female; education is differentiated according to education level, ranging from illiterate to Ph.D., respectively, on a scale of 1–8; and marriage is divided into two types: married and unmarried, with 1 indicating married. Income level is the respondent's score of their income in the local position, from high to low 1–5. Work status is classified as having a job or not, with a value of 1 assigned to having a job and 0 to not having a job.

2.3. Statistical analysis

This study first verifies the effect of urban-rural disparities on the mental health of the population, and the OLS regression model is shown in Equation (1):

$$\mathbf{health_i} = \alpha_0 + \alpha_1 \mathbf{urban_i} + \delta_{1c}\mathbf{X_i} + \varepsilon_{1i} \tag{1}$$

Where $health_i$ is the explanatory variable, which contains mental health. $Urban_i$ is the core independent variable. X_i is a set of control variables. The estimated coefficient α_1 is the coefficient of the urban-rural effect on mental health, which determines the existence of urban-rural mental health inequalities according to whether it is significant or not. The positive or negative of α_1 determines the specific manifestation of urban-rural mental health inequalities. ε_i is a random disturbance term.

In addition, Equations (1)–(3) is the mediating effect model developed in this paper, where $Internet_i$ is the mediating variable representing whether or not to use the Internet. To test the mediating effect of Internet use, we choose the bootstrap method. The bootstrap method uses the study sample as the overall sample, and repeatedly draws a certain number of samples from the study sample by means of put-back sampling, and takes the mean value of the parameters obtained from each sample as the final estimation result. This method has high statistical validity and can make the parameter estimation of the model more accurate (42). In this paper, the Bootstrap mediation test with 500 repetitions of sampling was conducted using stata16 software.

$$\mathbf{Internet_i} = \beta_0 + \beta_1 \mathbf{urban_i} + \delta_{2c}\mathbf{X_i} + \varepsilon_{2i} \tag{2}$$

$$\mathbf{health_i} = \gamma_0 + \gamma_1 \mathbf{urban_i} + \gamma_2 \mathbf{internet_i} + \delta_{3c}\mathbf{X_i} + \varepsilon_{3i} \tag{3}$$

3. Results

3.1. Descriptive results

According to the results in Table 1, the mean value of mental health is 13.439, indicating that the majority of respondents are not so depressed; the mean value of household registration status is 0.281, indicating that 28.1% of the respondents are urban households; the mean value of the Internet is 0.213, representing only 21.3% of the respondents use the Internet, which indicates that the penetration rate of the Internet in China is not so high; the mean age of the interviewees is 44.263, indicating that the majority of respondents are middle-aged. In addition, 50.5% of the respondents are male, 43.4%

TABLE 1 Descriptive statistics of the variables.

	N	Mean	SD	Min	Max
Mental health	24,525.000	13.439	4.048	8.000	32.000
Urban household registration	22,948.000	0.281	0.450	0.000	1.000
Internet	24,904.000	0.213	0.409	0.000	1.000
Age	28,590.000	44.263	19.467	9.000	104.000
Gender	25,114.000	0.505	0.500	0.000	1.000
Marriage	23,048.000	0.7651	0.424	0.000	1.000
Income level	21,238.000	2.929	1.050	1.000	5.000
Edu	28,504.000	2.783	1.460	1.000	8.000
Work stage	22,932.000	0.782	0.413	0.000	1.000

are married and 78.2% are having work. There are no outliers in the sample.

3.2. Analysis of mental health inequalities between urban and rural residents

As shown in column (1) of Table 2, without control variables, the results of the baseline regression show the objective existence of mental health inequalities between urban and rural areas, with a regression coefficient of −0.912, which is significant at the 1% level, showing that urban respondents have better mental health than rural respondents. Besides, with control variables in the model, as shown in column (1) of Table 2, the results are still significant.

3.3. Analysis of the mediating effect of internet use

To further verify the mediating role of Internet use, this paper uses the bootstrap mediating effect measure to decompose the impact (Table 3). The estimated coefficient of direct effect is −0.49, and the estimated coefficient of indirect effect is −0.028, and all the two effects pass the 5% significance test. All coefficients are negative, indicating that urban-rural differences could affect respondents' mental health not only directly, but also indirectly through Internet use, indicating that the respondents could significantly improve their health status through the Internet.

TABLE 2 Regression results.

Variables	(1) Mental health	(2) Mental health
Urban household registration	-0.912^{***}	-0.484^{***}
	(0.060)	(0.069)
Control	No	Yes
_cons	13.797^{***}	17.776^{***}
	(0.032)	(0.183)
N	22,384.000	20,536.000
F	229.390	187.930

$^{***}p < 0.01$.

TABLE 3 Decomposition of the effect of urban and rural areas on mental health.

	Coefficient	Std. err.	$p > z$
Indirect effects	-0.028^{***}	0.009	0.009
Direct effect	-0.490^{***}	0.066	0.000

$^{***}p < 0.01$.

3.4. Robustness test

We used three methods for robustness testing. Firstly, using CFPS 2020 data, we conducted a selection test on the sample by removing a portion of the residents with the lowest depression score from the analyzed sample to test the mediating effect of Internet use in the remaining sample. As shown in column (1) of Table 4, the results show that the above study findings still hold. Secondly, using CFPS 2020 data, we used subjective wellbeing as a replacement variable, as shown in column (2) of Table 4, and the mediating effect test remains significant. Third, to enhance the causal inference validity, we used the CFPS longitudinal survey data from 2010 to 2020. As shown in columns (3) and (4) of Table 4, the mediating effect test results were significant for either depression or subjective wellbeing as a measure of mental health.

4. Discussion

This paper examined the current state of urban-rural mental health inequalities using regression analysis and analyzed the mediating role of Internet usage by Bootstrap mediating effect measure, and the following conclusions were drawn.

First, mental health inequalities between urban and rural residents exist objectively, mainly manifested by the fact that urban respondents have better mental health than rural respondents. The social-ecological system theory (43) suggests that individual health is influenced by many factors such as interpersonal, organizational, community, public policies, and social environment. Rural and urban residents differ in many ways, including education, income, organization, interpersonal, and living communities. People living in rural areas travel farther to receive care, they are less likely to have access to quality health care and visit healthcare providers frequently, and therefore have poorer health status. This is consistent with social-ecological systems theory and with the findings of other scholars (3).

TABLE 4 Robustness test result.

	CFPS (2020)		CFPS (2010–2020)	
	(1) Depression (unremoved sample)	(2) Subjective wellbeing	(3) Depression	(4) Subjective wellbeing
Indirect effects	-0.031^{***}	0.014^{**}	-0.025^{***}	0.003^{***}
	(0.012)	(0.006)	(0.005)	(0.0003)
Direct effect	-0.427^{***}	0.134^{***}	-0.682^{***}	0.021^{***}
	(0.066)	(0.031)	(0.032)	(0.002)

$^{**}p < 0.05$, $^{***}p < 0.01$.

Second, Internet use plays a partially mediating role in the formation of health inequalities between rural and urban residents, and the effect is tested by Bootstrap methods. This finding can be explained in two ways: first, in terms of the interpersonal affective aspects, Internet users will have more opportunities for social participation, social activities, and recreation (13, 14), which is beneficial to mental health. Second, in terms of information acquisition, the Internet is an important channel for people to obtain health information, and Internet users can use the Internet to acquire health knowledge, search for information on diseases, enhance health prevention and care, participate in online health activities, and improve their lifestyles to improve their health (44). The Internet is an important channel for people to obtain health information.

There are certain limitations in this study. There may be a reverse causal relationship between Internet use and residents' mental health. For example, loneliness may enhance residents' use of the Internet. But in this study, we measured mental health based on residents' level of depression in the past week, so this health indicator is immediate, whereas Internet use refers to Internet use "in the past year." Thus, there is a time lag between the respondents' mental health and Internet use variables, which may mitigate the possible endogeneity risk to some extent. However, although the potential endogeneity risk is relatively small, this does not completely address or avoid the possible endogeneity risk. Future studies can select other methods to better solve this problem. Despite the limitations, this work also has several strengths. Firstly, there are few studies on the relationship between Internet use and rural-urban mental health inequality, and the limited studies mainly take developed countries as samples, lacking research on developing countries. Secondly, this paper takes China, the largest developing country in the world, as a sample for research, which can provide experience for developing countries to eliminate rural-urban mental health inequality. Thirdly, most of the data selected in the existing research on this topic in China are not timely. In the new era of the Internet, this paper uses the latest CFPS 2020 data to test the objective existence and specific manifestations of rural-urban mental health inequality, therefore providing the latest empirical evidence in China.

5. Conclusion

This paper examined the current status of mental health inequalities between urban and rural residents using regression analysis and analyzed the mediating role of Internet use by the Bootstrap method. The results showed that mental health inequalities exist between urban and rural areas, and Internet use plays a mediating effect in it. Rural-urban health inequalities are an important topic for many countries around the world, and with the advent of the digital age, the use of the Internet provides new perspectives to explain rural-urban health inequalities. It is suggested that additional research on how increasing Internet access affects health in rural and urban areas is needed in the future.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by the Biomedical Ethics Review Committee of Peking University (ID: IRB00001052-14010). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

Conceptualization, data curation, writing, and writing—original draft: WN and MH. Methodology and writing—review and editing: WN, MH, and XY. Validation and supervision: XY. Formal analysis: WN and MH. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

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

Publisher's note

References

1. Wagstaff A, Lindelow M. Health reform in rural China: challenges and options. In: Lou J, Wang S, editors. *Public Finance in China: Reform and Growth for a Harmonious Society*. Washington, DC: World Bank (2008). p. 265–86. doi: 10.1596/978-0-8213-6927-2

2. Misra R, Mukherjee A, Peterson R. Value creation in virtual communities: the case of a healthcare web site. *Int J Pharm Healthc Market.* (2008) 2:321–37. doi: 10.1108/17506120810922358

3. Fang H, Chen J, Rizzo JA. Explaining urban-rural health disparities in China. *Med Care.* (2009) 47:1209–16. doi: 10.1097/MLR.0b013e3181adcc32

4. Zhang J, Chandola T, Zhang N. Understanding the longitudinal dynamics of rural-urban mental health disparities in later life in China. *Aging Mental Health.* (2022) 26:1–10. doi: 10.1080/13607863.2022.2098912

5. Wang Y, Hu M, Ding R, He P. The dynamic relationship between subjective social status and health: evidence from a Chinese cohort study. *Wiley Online Library.* (2022) 28:1–21. doi: 10.1111/bjhp.12608

6. Zhang L, Xu Y, Nie H, Zhang Y, Wu Y. The prevalence of depressive symptoms among the older in China: a meta-analysis. *Int J Geriatr Psychiatry.* (2012) 27:900–6. doi: 10.1002/gps.2821

7. Cheng Y, Gao S, Li S, Zhang Y, Rosenberg M. Understanding the spatial disparities and vulnerability of population aging in China. *Asia Pac Policy Stud.* (2019) 6:73–89. doi: 10.1002/app5.267

8. Li LW, Liu J, Zhang Z, Xu H. Late-life depression in rural China: do village infrastructure and availability of community resources matter? *Int J Geriatr Psychiatry.* (2015) 30:729–36. doi: 10.1002/gps.4217

9. Janc K, Siłka P. How big is the digital divide between rural and urban areas in Poland? *Studia Obszarów Wiejskich.* (2016) 43:45–58. doi: 10.7163/SOW.43.3

10. Salemink K, Strijker D, Bosworth G. Rural development in the digital age: a systematic literature review on unequal ICT availability, adoption, and use in rural areas. *J Rural Stud.* (2017) 54:360–71. doi: 10.1016/j.jrurstud.2015.09.001

11. Michailidis A, Partalidou M, Nastis SA, Papadaki-Klavdianou A, Charatsari C. Who goes online? Evidence of internet use patterns from rural Greece. *Telecommun Policy.* (2011) 35:333–43. doi: 10.1016/j.telpol.2011.02.006

12. Lengsfeld JHB. An econometric analysis of the sociodemographic topology of the digital divide in Europe. *Inform Soc.* (2011) 27:141–57. doi: 10.1080/01972243.2011.566745

13. Sun J, Lyu S. Social participation and urban-rural disparity in mental health among older adults in China. *J Affect Disord.* (2020) 274:399–404. doi: 10.1016/j.jad.2020.05.091

14. Reinfeld-Kirkman N, Kalucy E, Roeger L. The relationship between self-reported health status and the increasing likelihood of South Australians seeking Internet health information. *Aust NZ J Public Health.* (2010) 34:422–6. doi: 10.1111/j.1753-6405.2010.00576.x

15. Baldwin LM, MacLehose RF, Hart LG, Beaver SK, Every N, Chan L. Quality of care for acute myocardial infarction in rural and urban US hospitals. *J Rural Health.* (2004) 20:99–108. doi: 10.1111/j.1748-0361.2004.tb00015.x

16. Goh JM, Gao G, Agarwal R. The creation of social value. *MIS Q.* (2016) 40:247–64. doi: 10.25300/MISQ/2016/40.1.11

17. Chen Y, Yin Z, Xie Q. Suggestions to ameliorate the inequity in urban/rural allocation of healthcare resources in China. *Int J Equity Health.* (2014) 13:1–6. doi: 10.1186/1475-9276-13-34

18. Eriksson T, Pan J, Qin X. The intergenerational inequality of health in China. *China Econ Rev.* (2014) 31:392–409. doi: 10.1016/j.chieco.2014.06.005

19. Li H, Tracy MB. Family support, financial needs, and health care needs of rural elderly in China: a field study. *J Cross Cult Gerontol.* (1999) 14:357–71. doi: 10.1023/A:1006607707655

20. Zimmer Z, Kwong J. Socioeconomic status and health among older adults in rural and urban China. *J Aging Health.* (2004) 16:44–70. doi: 10.1177/0898264303260440

21. Shi L. Health care in China: a rural-urban comparison after the socioeconomic reforms. *Bull World Health Organ.* (1993) 71:723.

22. Sidel VW. New lessons from China: equity and economics in rural health care. *Am J Public Health.* (1993) 83:1665–6. doi: 10.2105/AJPH.83.12.1665

23. Xie Y, Hu J. An introduction to the China family panel studies (CFPS). *Chin Sociol Rev.* (2014) 47:3–29. doi: 10.2753/CSA2162-0555470101

24. Yu Z, Hu N, Du Y, Wang H, Pu L, Zhang X, et al. Association of outdoor artificial light at night with mental health among China adults: a prospective ecology study. *Environ Sci Pollut Res.* (2022) 29:82286–96. doi: 10.1007/s11356-022-21587-y

25. Ao CK, Dong Y, Kuo PF. Industrialization, indoor and ambient air quality, and elderly mental health. *China Econ Rev.* (2021) 69:101676. doi: 10.1016/j.chieco.2021.101676

26. Jiang W, Lu Y, Xie H. Education and mental health: evidence and mechanisms. *J Econ Behav Organ.* (2020) 180:407–37. doi: 10.1016/j.jebo.2020.09.032

27. Shojaee M, French C. The relationship between mental health components and locus of control in youth, psychology. *Sci Res.* (2014) 966–78. doi: 10.4236/psych.2014.58107

28. Heaslip V, Vahdaninia M, Hind M, Darvill T, Staelens Y, O'Donoghue D, et al. Locating oneself in the past to influence the present: impacts of Neolithic landscapes on mental health well-being. *Health Place.* (2020) 62:102273. doi: 10.1016/j.healthplace.2019.102273

29. Cao D, Zhou Z, Liu G, Shen C, Ren Y, Zhao D, et al. Does social capital buffer or exacerbate mental health inequality? Evidence from the China Family Panel Study *(CFPS). Int J Equity Health.* (2022) 21:1–17. doi: 10.1186/s12939-022-01642-3

30. Abdel-Khalek A, Lester D. Mental health, subjective well-being, and religiosity: Significant associations in Kuwait and USA. *J Muslim Mental Health.* (2013). 7:e204. doi: 10.3998/jmmh.10381607.0007.204

31. Song Q, Smith JP. Hukou system, mechanisms, and health stratification across the life course in rural and urban China. *Health Place.* (2019) 58:102150. doi: 10.1016/j.healthplace.2019.102150

32. Cohen G. Age and health status in a patient satisfaction survey. *Soc Sci Med.* (1996) 42:1085–93. doi: 10.1016/0277-9536(95)00315-0

33. Braveman P, Egerter S, Williams DR. The social determinants of health: coming of age. *Annu Rev Public Health.* (2011) 32:381–98. doi: 10.1146/annurev-publhealth-031210-101218

34. Doyal L. Sex, gender, and health: the need for a new approach. *BMJ.* (2001) 323:1061–3. doi: 10.1136/bmj.323.7320.1061

35. McDonough P, Walters V. Gender and health: reassessing patterns and explanations. *Soc Sci Med.* (2001) 52:547–59. doi: 10.1016/S0277-9536(00)00159-3

36. Leigh JP. Direct and indirect effects of education on health. *Soc Sci Med.* (1983) 17:227–34. doi: 10.1016/0277-9536(83)90120-X

37. Ross CE, Mirowsky J. The interaction of personal and parental education on health. *Soc Sci Med.* (2011) 72:591–9. doi: 10.1016/j.socscimed.2010.11.028

38. Hoch JS, Briggs AH, Willan AR. Something old, something new, something borrowed, something blue: a framework for the marriage of health econometrics and cost-effectiveness analysis. *Health Econ.* (2002) 11:415–30. doi: 10.1002/hec.678

39. Koball HL, Moiduddin E, Henderson J, Goesling B, Besculides M. *What do We Know About the Link Between Marriage and Health?* Sage Publications Sage CA: Los Angeles, CA (2010). doi: 10.1177/0192513X10365834

40. Benzeval M, Judge K. Income and health: the time dimension. *Soc Sci Med.* (2001) 52:1371–90. doi: 10.1016/S0277-9536(00)00244-6

41. Llena-Nozal A. The effect of work status and working conditions on mental health in four OECD countries. *Natl Inst Econ Rev.* (2009) 209:72–87. doi: 10.1177/0027950109345234

42. Hayes AF. *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach.* New York, NY: Guilford Publications (2017).

43. Bronfenbrenner U. Toward an experimental ecology of human development. *Am Psychol.* (1977) 32:513. doi: 10.1037/0003-066X.32.7.513

44. Faraj S, Kudaravalli S, Wasko M. Leading collaboration in online communities. *MIS Q.* (2015) 39:393–412. doi: 10.25300/MISQ/2015/39.2.06

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Can heart rate variability be a bio-index of hope? A pilot study

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Background: Hope can affect the thinking habits, emotional regulations, and behaviors of individuals. Hope is considered as a positive trait by clinicians, who often assess the level of hope in psychological evaluations. Previous measurements of hope were largely based on self-reported questionnaires leading to the problem of subjectivity. Heart Rate Variability (HRV) is a bio index that is an objective, quick, cost effective, and non-invasive measurement. HRV has been used in the evaluation of physical health and some psychiatric conditions. However, it has not been tested for its potential to be a bio-index of the level of hope.

Method: This pilot cross-sectional observational study aimed to examine the relationships between HRV and the level of hope among adult Chinese people in Hong Kong. Convenience sampling was used and 97 healthy participants were recruited. Their level of hope was measured by the Dispositional Hope Scale-Chinese (DHS-C), and their HRV was quantified by emWave Pro Plus, a reliable sensor of HRV. Spearman's correlation coefficient analysis was performed on the HRV measurements and DHS-C.

Results: The DHS-C's overall mean score was 45.49. The mean scores of the subscale DHS-C (Agency) was 22.46, and the mean scores of DHS-C (Pathway) was 23.03. It was also revealed that there were significant, weak, and negative correlations between the level of hope and four out of ten HRV metrics. One HRV metric was found to have a significant, weak, and positive correlation with the level of hope.

Conclusion: This study provided initial evidence to support the use of HRV as a bio-index of hope. Implications of the current study and recommendations for future research directions are discussed.

KEYWORDS

Heart rate variability, HRV, hope, psychological well being, positive psychology

1. Introduction

Hope has long been considered as an important therapeutic factor in psychology, medicine and nursing. Without hope, humans struggle to survive during challenging times. Hope can affect the thinking habits, emotional regulations, and behaviors of individuals (1). Individuals who are hopeful tend to have more goal-oriented thinking because this thinking style is rewarded by positive consequences (2, 3). Hope may also affect the emotion regulation processes of individuals; Peh et al. (4) conducted a path analysis to investigate whether hope mediates the association between reappraisal and anxiety/depression in patients newly diagnosed with cancer ($N = 144$). The result of study indicated that a higher level of reappraisal was correlated with lower levels of negative emotions and hope also mediated the linkages between reappraisal and negative emotions. Hope can also affect the behaviors of individuals. Dixson (5) conducted a cluster analysis which yielded three clusters of hope (high, average, and low) in high school and college students ($N = 852$). Differences among hope clusters were examined across three domains of indicator variables—(engagement, disengagement, and motivation)—associated with success-oriented behavior in school. The study finally revealed that hope could cause individuals to engage in more success-oriented behaviors (5).

Hope may also influence how people strive to achieve goals. Snyder et al. (2) described two different types of hope: dispositional hope and state hope. Dispositional hope is a trait like characteristic of individuals, which supports individuals to feel constantly hopeful. Whereas, state hope referred to current goal directed thinking, which occurred in short periods of time (6). Dispositional hope contained two interrelated cognitive dimensions: agency and pathway. Agency was the determination and commitment of individuals to help them move to the directions of goals (7). Agency thinking was the perceived capability of and motivation for achieving a desired goal. Individuals, who were high in this dimension, tended to empower themselves by self-talk phrases like, “I can do this all day” or, “I am not going to be stopped” (8). Pathway was described as the perceived capacity of individuals to achieve their goals and set up different plans to overcome the obstacles (7). Pathways thinking referred to the act of evaluating the availability of different resources and methods to reach the desired goals (3). Individuals who were considered as high in the pathways dimension tended to be more decisive and confident about creating workable routes for attaining the desired goal (8). In summary, hope was found to be a positive trait which constantly empowers individuals to seek possible pathways to achieve their desired goals (7).

Despite the potential importance of hope in influencing behaviors, it’s measurement in research studies is challenging. Previous measurements of hope are largely based on self-reported questionnaires, which include different scale including but not limited to the Work Hope Scale (9), Social Hope Scale (10), Locus-of-Hope Scale (11), and Dispositional Hope Scale (2). However, these scales have several fundamental problems in their design. Firstly, there is a problem of central tendency bias, which referred to the avoidance of participants to give answers on both extremes of the Likert scale, and the participants tended to respond in the mid-point (12). The second problem with self-reported questionnaires is that respondents’ answers may be heavily influenced by social desirability. Finally, the participants may have misconceptions about the wordings of the questions, since they are perceiving the questionnaires subjectively, which may be different from the original meanings of words used by the designers (13). In addition, the researchers using these measures require training. They are expensive and by nature the self-completed measures lack objectivity as they rely purely on self-report. Whereas bio indexes are objective, quick, cost effective, and non-invasive measurements.

Using bio-indexes to facilitate the assessment process is not new. For example, hospital nurses or physicians frequently use pulse rate, breathing rate, and blood pressure to investigate if individuals are anxious. Apart from these traditionally used bio-indexes, Heart rate variability (HRV) is a relatively new biometric which measures the fluctuation of time intervals between consecutive heartbeats (14). The variability of the heartbeat determines the capacity to the heart of individuals to alter their level of functioning to manage the changing external environment (15).

Previous studies demonstrated that Heart Rate Variability (HRV) could be an indicator of some physical health problems such as myocardial infarction, sepsis, trauma, sleep apnea, chronic fatigue and cardio-respiratory illnesses (16). Laborde et al. (17) proposed the neural pathway involved in the regulation of the autonomic nervous system (ANS) supports adaptive responses to the environment, stressors, and social behaviors (18). The heart’s activities increase in order to support rapid mobilization of metabolic resources which are required to prepare for appropriate actions (e.g., fight or flight response) (19).

Recent research has also revealed that HRV could reflect different psychiatric conditions, such as anxiety disorder, depression, post-traumatic stress disorder, daily mental stress and prolonged work stress (20–26). HRV can also provide an indication of mental wellbeing such as having good life satisfaction, a high level of positive affect and a low level of negative affect (27, 28). In summary, individuals with different ANS activities could have different HRV patterns. Hence, HRV could be used as bio-indexes of different mental health conditions.

Another direction of research on the usage of HRV on mental health was to investigate the correlations of HRV with positive psychological traits (i.e., resilience). Some studies demonstrated that HRV could be the biomarker of resilience, which is usually defined as a trait of individuals that help them adapt and bounce back from traumatic events or adversities, as it reflects the ability of individuals to maintain a stable equilibrium during stressful events (29, 30). Although recent research indicated that HRV could be bio-indexes of resilience, the possibilities of using HRV as the bio-index of other similar positive psychological traits such as hope have not been studied. The purpose of the current pilot study aimed to fill this research gap, which explored the possible correlations between HRV metrics and hope. If significant correlations between HRV metrics and hope were identified, new bio-indexes for hope would be established. As such, HRV would be able to be considered an alternative objective method to measure hope, without the inherent potential limitations of relying solely on self-reported questionnaires.

2. Theoretical framework

Polyvagal theory, which was proposed by Porges (18), provided a tenet for this study. According to this theory, the vagus nerve is a brake that actively inhibits the effect of the sympathetic nervous system (SNS) on heart activity to ensure individuals remain calm and relaxed when at rest. However, when individuals encounter stressful situations this vagal brake is rapidly reduced.

Once the brake is released, then the heart's activities increase in order to support rapid mobilization of metabolic resources which are required to prepare for appropriate action (e.g., fight or flight response) (19). Hence, the polyvagal tone could affect the activities of the ANS and the cognitive reappraisal of events and emotion regulations are also linked with cardiac vagal function. Meanwhile, hope could affect the cognitive reappraisal of events and emotional regulation capacities of individuals. Therefore, with regards to Polyvagal theory, hope should be linked with cardiac vagal function, which regulates the activities of ANS. As a result, the individuals' difference in the level of hope should have effects on the polyvagal tone as well as the ANS, which could be measured by HRV. Hence, people with different levels of hope should have different patterns of HRV metrics. **Supplementary Figure 1** illustrates the above-mentioned relationship.

3. Research questions

An individual's level of hope can affect their capacities of emotion regulation and cognitive reappraisal, which impacts ANS activities. Given that alternations of the activities of ANS are revealed by HRV (31), differences in the level of hope should be reflected by the patterns of HRV metrics among different individuals. Thus, the HRV metrics could serve as bio-indexes of hope. In fact, as revealed by the literature review, HRV has been found to be able to serve as a biomarker of resilience, a similar psychological trait to hope. Therefore, the current research addresses the following research questions:

RQ1. To what extent is there a correlational relationship between HRV and the level of hope? RQ2. What is the overall level of hope among Hong Kong Chinese Adults?

4. Materials and methods

4.1. Study design

This study used a cross-sectional observational survey design to examine the relationships between HRV and the level of hope among adult Chinese people in Hong Kong.

4.2. Ethical consideration

Ethical approval was obtained from the Institutional Review Board (IRB) of the California Southern University (the institute where the first author completed his doctoral degree) before recruitment and data collection. All participants provided written informed consent. Participants were aware that taking part was voluntary and that they could withdraw from the study at any point without penalty. No monetary incentive was given to the participants.

4.3. Study setting

The researchers sent out online invitation letters *via* email, Facebook, and Instant Messenger of Smartphone (WhatsApp's and Line) to invite participants to join the study in November 2021 in Hong Kong. The online invitation letters contain information including the purpose and nature of the study, measures to protect their privacy, participant inclusion and exclusion criteria, locations, duration, and procedures of the data collection, their rights to participate and withdraw from the study, the potential risk, and benefits of participating in this study as well as the contact information of the researcher.

4.4. Recruitment and data collection

The interested participants were invited to sign-up for a data collection session and were asked to input their information related to the participant inclusion and exclusion criteria *via* a Google form and select a preferred timeslot for data collection. Only the applicants who met the inclusion criteria were included in the study. Participants received a confirmation letter of the arrangements for data collection. The letter also detailed several precaution measures because these activities may affect the HRV readings. This included advice that participants should refrain from heavy aerobic exercise or consuming coffee, tea or other caffeinated beverages at least 1 h before data collection. Participants were also informed that they should not eat a heavy meal for at least one and a half hours before the assessment. In addition, they should be non-smokers. Recruitment and data collection were conducted from November 2021 to December 2021.

Data were collected at a University nursing laboratory. On the day of the data collection, the researcher initially confirmed whether the participants had followed the precautions measures and explained the purpose and the procedure of the study. After obtaining their informed consent, the researcher measured the vital signs (blood pressure, heart rate, and temperature), height and weight. The researcher assessed if the vital signs and their Body Mass Indexes (BMI) were within the normal range (i.e., BMI 18.5–22.9) and requested the participants to confirm they had no major illnesses. After that, the participants were invited to use their smartphone to click a link, which lead them to Qualtrics (i.e., an online platform for questionnaire-based research). They were requested to complete the online DHS-C and provide their demographic data (age, gender, educational level, marital status, and income) *via* the online form. Data from the online based questionnaires were stored on Qualtrics, which required the researcher's login ID and password to access.

After the participants completed the questionnaires, their HRV was assessed by the emWave Pro Plus device in a quiet and air-conditioned room (between 23–25 degrees Celsius), so that no other unnecessary external stimulus, such as background noise, could affect the HRV parameters. During the HRV assessments, the participants were advised to sit in a comfortable chair with a backrest without talking, falling asleep, crossing legs, and making unnecessary movements which might cause unwanted artifacts. In addition, they were advised to open their eyes, while avoiding reading or engaging in intense mental activity during the HRV assessment. The sensor of the device was attached to the earlobe of the participant and the researcher confirmed that the signals were captured and visualized by the computer. The HRV data collection lasted for 5 min. The HRV data was stored within the computer of the researcher. The computer, which was locked with login ID and password, was stored inside a secure locker. All data including the HRV data, and the online questionnaire data was transferred onto a physical hard drive, which was encrypted. The hard drive will be stored in a locker in the research office for 5 years. Following the usual practice in handling research data, the data of in the hard drive would be deleted after 5 years (32).

4.5. Participants

Convenience sampling was used in this study. Those whose age ranged from 18–65 years and were able to read and write Chinese were included in this study. Those who had major illnesses (such as cardiovascular, endocrine, neurological, and psychiatric disorders), obesity or a history of alcohol, tobacco or substance misuse were not eligible to participate, as these problems might serve as confounding variables that can influence the baseline HRV measurements.

4.6. Variables

The Chinese version of the Dispositional Hope Scale was used to quantify the level of hope among the participants. Ten HRV metrics [Very Low Frequency (VLF), Low Frequency (LF), High Frequency (HF), Total Power (TP), Normalized Coherence (NC), Mean Heat Rate Range (MHRR), Mean Heart Rate (MHR), Standard Deviation of the Normal-to-Normal sinus-initiated interbeat-intervals measured in milliseconds (SDNN), Root Mean Square of Successive Differences between normal heartbeats (RMSDD), and Mean Interbeat Interval (MIBI)] were assessed by emWave Pro Plus, a reliable device to quantify HRV by using Photoplethysmography (PPG) technology.

4.7. Measurements

4.7.1. Dispositional Hope Scale–Chinese

The level of hope was measured by the Dispositional Hope Scale, Chinese version (DHS-C) (33). The original Dispositional Hope Scale (DHS) was developed based on Snyder's Hope theory (2). It used 4-point Likert (i.e., ranging from 1 = definitely false, 2 = mostly false, 3 = mostly true, and 4 = definitely true) and consisted of 12-items, which contributed to the total score of the scale. The scale is comprised of two subscales: agency thinking (i.e., contained four items) and pathways thinking (i.e., contained four items). The remaining four items were used as filter items. Low total scores indicated a respondent's low level of hope while high scores indicated the opposite. DHS is a well validated (validity: 0.71–0.84; reliability: 0.73–0.85) tool to assess dispositional hope among college students and patients. (2) The scale was translated and validated to Chinese as Dispositional Hope Scale, Chinese Version (DHS-C) by Sun et al. (33). It used 8-point Likert (i.e., 1 = definitely false to 8 = definitely true) with the same 12-items and two subscales as the original version. The DHS-C, which demonstrated good structural validity (i.e., $\Delta\chi 2(1) = 9.04, p < 0.01$; CFI = 0.95) with 2-factor model of hope, was reported to have good psychometric properties and be suitable to assess the level of hope among Chinese people (33). Permission to use this scale was obtained from the author before the start of this study.

4.7.2. emWave pro plus

In this study, the metrics of heart rate variability (HRV) were captured by the emWave® Pro Plus system (HeartMath LLC., Boulder Creek, CA, United States). This tool, which applies photoplethysmography (PPG) technology, was able to detect and analyze the blood pulse wave through the skin. The wave in the blood stream is captured by a sensor, which should be attached to the ear lobe of the subjects. The data is then sent to the computer (MacBook Pro, 13-inch, M1, 2020) with emWave Pro Plus software (version 3.10.0.11205) for analysis. The device can provide two major domain measures of HRV; a time domain measure and a frequencies domain measure (34). The time domain related HRV metrics include the Mean InterBeat Interval (MIBI) and the Mean Heart Rate Range (MHRR). These parameters provide clinical information for effective analysis of the alternations of the heart rates of individuals caused by the actions of the SNS and PNS (15, 34). The Standard Deviation of all normal Interbeat Interval (SDNN) is considered as the gold standard of cardiac risk and Root Mean Square of Successive Difference (RMSSD) is associated with higher risk of sudden unexplained death among patients with epilepsy (15). In addition to the HRV metrics, the emWave Pro Plus also measured the Mean Heat Rate (MHR) for analysis.

The measures related to the frequency domain offered valuable clinical information about the functioning of the ANS, including the TP, VLF, LF, HF, and NC. PPG technology was considered as a reliable and valid method of capturing and quantifying HRV (35). The emWave Pro Plus has been used extensively in published research involving HRV measurements (36–40).

4.8. Study size

As there was no previous study investigating the correlations between HRV and hope in a Chinese context, the expected correlation was taken from a relevant local study, which investigated the correlations between stress and HRV among Chinese people (41). In Low and McCraty's (41) study, the research designers estimated the correlation r as 0.3. To achieve a power of 0.8, an estimated correlation r of 0.3, with a significance level 0.05, the total sample size needed for this study was 85 participants (42).

4.9. Data analysis

Data were analyzed by Statistical Package for Social Science version 23 (SPSS) software. Missing values analysis was done and no patterns in missing data were detected. Subsequently, pairwise deletion was used to deal with missing data. Frequency and percentages were used to describe demographic data variables: gender, age, marital status, educational level, and family income. The total score of the DHS-C was used to measure the overall level of hope of participants.

After establishing that data were normally distributed, Spearman's correlation coefficient analysis was performed on HRV measurements (MIBI, SDNN, RMSSD, MHRR, MHR, NC, TP, VLF, LF, and HF) and the score of DHS-C in order to investigate the correlational relationships among these variables and answer RQ1: To what extent is there a correlational relationship between HRV and the level of hope. The significance or alpha level for these analyses was set at $p < 0.05$.

5. Results

5.1. Participants

Overall, 102 individuals expressed an interest to participate in the research. However, five did not attend the assigned day for data collection. Finally, 97 individuals met the inclusion criteria and did not have any conditions listed in the exclusion criteria. They signed the consent forms and participated in the study (**Supplementary Figure 2**).

More than half of participants (n = 53, 54.6%) were male and the age ranged from 18 to 30 (53.6%). Nearly two-thirds of participants were single (n = 66; 68%). Most participants possessed an education of at least of Bachelor level (34%; n = 33). Overall, 29.9% (n = 29) of the participants had a Master's degree, and 6.2% (n = 6) were educated up to doctoral level. Most of the participants (35.1%; n = 34) reported that their family income was above $50,000 Hong Kong Dollars per year. The demographic characteristics of the participants are presented in **Supplementary Table 1**.

5.2. The overall level of hope among Chinese adults

Of the total 97 respondents, the DHS-C (Total)'s overall mean score was 45.49, ranging from 12 to 96, with the standard deviation of 5.350. The mean scores of the subscale DHS-C (Agency) was 22.46, ranging from 4 to 32, with the standard deviation of 2.909. The mean scores of DHS-C (Pathway) was 23.03, ranging from 4 to 32, with the standard deviation of 3.306. Details of the scores are summarized in **Supplementary Table 2**.

5.3. Correlational relationship between HRV and the DHS-C (total scale)

Referring to **Supplementary Table 3**, four HRV metrics were found to be significantly, negatively, and weakly correlated to the total scale of DHS-C, which includes HF (r = −0.286, n = 97, p = 0.004), SDNN (r = −0.224, n = 97, p = 0.027), MIBI (r = −0.227, n = 97, p = 0.025), and RMSSD (r = −0.214, n = 97, p = 0.035). Three HRV metrics showed trends toward significant and negative correlations with the total score of DHS-C. These include VLF (r = −0.187, n = 97, p = 0.067), TP (r = −0.189, n = 97, p = 0.067), and LF (r = −0.155, n = 97, p = 0.131). However, MHR was significantly and positively correlated with the total scale of DHS-C (r = −0.223, n = 97, p = 0.028). The research results provide initial evidence that HRV metrics (HF, SDNN, RMSSD, and MIBI) could be considered as bio-indexes of the level of hope among individuals.

5.4. Correlational relationship between HRV and the DHS-C-pathway

Referring to **Supplementary Table 4**, Spearman's Correlation analysis was conducted to analyze the correlations between DHS-C-pathway and HRV metrics. Significant and weak correlational relationships between 3 of the HRV metrics and the DHS-C-Pathway were observed. There was a significant correlation between the DHS-C-Pathway and HF (r = −0.261, n = 97, p = 0.010). Another significant correlation was observed between DHS-C-Pathway and RMSSD (r = −0.226, n = 97, p = 0.026). MHR was also significantly correlated with DHS-C-Pathway (r = 0.200, n = 97, p = 0.050). In addition, MIBI was observed to have significant correlation with DHS-C-Pathway (r = −0.204, n = 97, p = 0.045). There appeared to be a trend toward a significant negative correlation between DHS-C-Pathway scores and VLF (r = −0.188, n = 97, p = 0.066). Another trend between DHS-C-Pathway scores and SDNN was observed (r = −0.195, n = 97, p = 0.056).

5.5. Correlational relationship between HRV and the DHS-C-agency

Referring to **Supplementary Table 5**, Spearman's Correlation analysis was done to analyze the correlations between DHS-C-Agency and HRV metrics. Significant correlational relationships between 1 of the HRV metrics and the DHS-C-Agency were observed. There was a significant and weak correlation between the DHS-C-Agency and HF (r = −0.243, n = 97, p = 0.016). There appeared to be a trend toward a significant negative correlation between DHS-C-Agency scores and SDNN (r = −0.195, n = 97, p = 0.056). Another trend between DHS-C-Agency scores and MIBI was observed (r = −0.189, n = 97, p = 0.063). Finally, there was a trend between DHS-C-Agency scores and MHR (r = −0.187, n = 97, p = 0.067).

6. Discussion

This is the first study providing initial evidence to support the potential use of HRV metrics as bio-indexes of hope. The results indicate that there were significant, weak, and negative correlations between most of the HRV metrics (i.e., HF, SDNN, RMSSD, and MIBI) and the level of hope. There was also a trend toward significant negative correlations observed on VLF, TP, and LF of HRV metrics. Hence, individuals with a higher level of hope tended to have a lower level of HRV metrics including HF, SDNN, RMSSD, MIBI, VLF, TP, and LF. The results also revealed that the subscales (Pathway) tend to have more negative correlations with HRV indexes. This result indicates that an individual's act of evaluating the availability of different resources and methods to reach the desired goals tend to have negative impacts on HRV indexes.

Previous studies revealed that individuals with a lower level of HRV metrics tend to have poor health status, such as immune dysfunction and inflammation, cardiovascular disease, and mortality [Dekker et al. (43); Fang et al. (44); Kemp and Quintana (45)]. In addition, the current study revealed that higher level of hope was positively correlated with higher level of MHR, which was measured at resting status in this study. Higher resting heart rate could be seen as an index of poorer cardiovascular health and cardiovascular disease such as hypertension (46). In other words, positive traits, such as hope, can bring positive mental health outcomes for individuals (47) but they might impose negative effects on physical health in the population being studied.

The phenomenon observed in the present study could be explained by Segerstrom's (48) Engagement Hypothesis. Segerstrom (48) proposed that individuals with more positive traits (e.g., optimism) tended to have more active engagement to the stressful environment during periods of adversity. These individuals believed that the active engagement with stressors could lead to termination of their stressor by participating in more problem-solving activities. However, if the circumstances were too challenging or demanding, individuals with more positive traits (e.g., optimism) tended to have poorer immunity, because these traits resulted in individuals being continuously focused on the stressful situation in an attempt to resolve the issues (49). In contrast, if the individuals had fewer positive traits (e.g., more pessimistic), they tended to give up more easily, disengage, and avoid active engagement in coping against the adversities. Hence, their physiological functioning, such as level of immunity, was less affected by the extreme environment. One previous study of the relationship between HRV and resilience (a positive trait similar to hope), revealed that the score of resilience was also negatively correlated to HRV metrics (LF and HF) which echoes our findings (29). In addition, An et al. (29) study also reported that higher scores in resilience were significantly and positively correlated with more adaptive engagement to adverse situations, i.e., an individuals' tendency to actively participate in more adaptive behaviors during a challenging time (29). In other words, individuals with more positive traits (e.g., hope, optimism, and resilience) could have greater engagement with stressors during extreme situations, resulting in higher levels of demand on physiological functioning. In contrast, participants with lower levels of hope tended to have less engagement with adverse situations, resulting in fewer demands on physiological functioning. Even though people with positive traits were more likely to handle a higher level of stress and were apparently not distressed by it, stress could be reflected by objective measurements like HRV. The negative associations between HRV metrics and hope observed in the current study may have been due to participants' active engagement with the stressful environment during COVID-19. During this study, the research participants were residing in Hong Kong during the COVID-19 pandemic; threats of infections, mandatory quarantine, lockdowns, and layoffs were seriously affecting the metropolitan. Most of the Hong Kong citizens were suffering from a greater level of stress (i.e., increased by 28.3%) and anxiety (i.e., increased by 42.3%), and the depression symptoms and unhappiness have doubled since COVID-19 outbreak when compared to 2016 and 2017 (50). With that premise, the Engagement Hypothesis could be applied, because the environments became demanding and challenging as evidenced by the elevated stress among the Hong Kong people.

As indicated in the Engagement Hypothesis, individuals, who possessed more of these positive traits (e.g., hope, optimism, and resilience), tended to be more engaged in the stressful environments. This difference was because these individuals tended to believe that they could tackle the stressors. The more frequent exposure to stressors may have resulted in a higher level of stress and extra physiological costs, which were captured by the reduced HRV metrics. Hence, negative and significant correlations were observed between the HRV metrics and hope in the current study.

6.1. Study limitations

The current study is limited by several factors. Firstly, it used a cross-sectional design. The primary limitation of this kind of research is that the researchers are not able to demonstrate temporal relationships between the variables. This is because these variables are measured and exposed at the same time. Secondly, as this study did not receive any funding support, the researchers had limited resources necessitating the use of convenience sampling. The major disadvantage of this sampling method is that the result may not be generalized to the wider population.

6.2. Recommendations for further research

Future research in the area should aim to replicate this study using a representative sample (including diverse ethnic groups) to estimate the possibility of using HRV metrics as bio-indexes of other positive psychological traits (i.e., optimism, wisdom, personal mastery, perceived self-efficacy, coping, creativity, conscientiousness, and spirituality and religiosity). Future studies should also consider conducting the research after the COVID-19 pandemic has resolved to examine any changes in the direction of the correlational relationships between HRV metrics and hope. In addition, this study identified significant, but weak correlations between HRV parameters and hope scales, which provides initial evidence for supporting to consider HRV as a possible bio-index of hope. However, previous literature indicated that other similar traits (e.g., resilience) also produced similar findings (29). Therefore, the research results should be interpreted with caution. A larger study that includes a range of other potentially confounding variables is recommended to identify which traits (e.g., hope or resilience) contribute to the HRV indexes before using HRV indexes as complementary measurements of hope. On the other hand, this study revealed that individuals, who scored high in the DHS-C, tended to have lower HRV. Future study is also needed to investigate the potential mediating relationships between engagement with stressors and HRV.

7. Implications

The results of current study provide initial evidence to support the use of HRV as a bio-index of hope. If researchers are able to generate more evidence which supports the linkage between HRV and hope in subsequent larger studies, then clinicians should consider using HRV metrics to assess the level of hope of their clients during clinical practice or/and research, alongside the self-report questionnaire. This approach could increase the objectivity of psychological evaluations and result in more reliable research outcomes. Measuring HRV is also cost effective, efficient, non-invasive, and straightforward.

The second implication for professional practice was that it alleviated the problem of assessment and re-assessment period of questionnaire-based clinical evaluation on the level of hope. In many questionnaire-based psychometric tests, time intervals between questionnaire administrations are required. Some researchers suggest that this time interval should range from 2 days to 2 weeks (51). Therefore, frontline psychologists had to wait until the next session to review the progress of their intervention. This problem also applied to the measurements of hope as they traditionally rely on questionnaire-based assessment. As the results indicated that HRV metrics have the potential to be a bio-index of this trait, the frontline psychologists could use the HRV metrics to evaluate and re-evaluate the level of hope within the same session. This change of practice provided a more direct and instant way for the frontline psychologists to review the effectiveness of their treatment. However, this second implication is subjected to the results of future study.

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 California Southern University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

YH and WW contributed to the conception and design of the study. YH and MT organized the database. YH performed the statistical analysis. YH, WW, and DB wrote the first draft of the manuscript. YH, YL, MT, HP, DB, and WW wrote sections of the manuscript. All authors contributed to the manuscript revision, read, and approved the submitted version.

Conflict of interest

HP was employed by Hong Kong Psychological Services Center Limited.

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.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1119925/full#supplementary-material

References

1. Leite AD, Medeiros A, Rolim CS, Pinheiro KS, Beilfuss MF, Leão MD, et al. Hope theory and its relation to depression: a systematic review. *Ann Psychiatry Clin Neurosci.* (2019) 2:1014. doi: 10.1093/milmed/usaa052

2. Snyder CR, Harris C, Anderson JR, Holleran SA, Irving LM, Sigmon ST. The will and the ways: development and validation of an individual differences measure of hope. *J Personal Soc Psychol.* (1991) 60:570–85. doi: 10.1037/0022-3514.60.4.570

3. Duncan AR, Jaini PA, Hellman CM. Positive psychology and hope as lifestyle medicine modalities in the therapeutic encounter: a narrative review. *Am J Lifestyle Med.* (2021) 15:6–13. doi: 10.1177/1559827620908255

4. Peh CX, Liu J, Bishop GD, Chan HY, Chua SM, Kua EH, et al. Emotion regulation and emotional distress: the mediating role of hope on reappraisal and anxiety/depression in newly diagnosed cancer patients. *Psychooncology.* (2017) 26:1191–7. doi: 10.1002/pon.4297

5. Dixson DD. Hope into action: how clusters of hope relate to success-oriented behaviors in school. *Psychol Sch.* (2019) 56:1493–511.

6. Alfieri, S, Quartiroli A, Baumann D. Adaptation of the Snyder's dispositional Hope Scale for Italian adolescents. *Curr Psychol.* (2021) 1–10. doi: 10.1007/s12144-021-01875-5

7. Long KNG, Kim ES, Chen Y, Wilson MF, Worthington EL Jr, VanderWeele TJ. The role of Hope in subsequent health and well-being for older adults: an outcome-wide longitudinal approach. *Glob Epidemiol.* (2020) 2:100018.

8. Yotsidi V, Pagoulatou A, Kyriazos T, Stalikas A. The role of hope in academic and work environments: an integrative literature review. *Psychology.* (2018) 9:385–402.

9. Juntunen CL, Wettersten KB. Work hope: development and initial validation of a measure. *J Couns Psychol.* (2006) 53:94–106.

10. Jin B, Kim YC. Rainbows in the society: a measure of hope for society. *Asian J Soc Psychol.* (2019) 22:18–27.

11. Bernardo A, Mendoza NB. Measuring hope during the COVID-19 outbreak in the Philippines: development and validation of the state locus-of-Hope scale short form in Filipino. *Curr Psychol.* (2021) 40, 5698–707. doi: 10.1007/s12144-020-00887-x

12. Pimentel JL. Some biases in likert scaling usage and its correction. *Int J Sci Basic Appl Res.* (2019) 45:183–91.

13. Demetriou C, Ozer BU, Essau CA. Self-report questionnaires. In: Cautin RL, Lilienfeld SO editors. *The encyclopedia of clinical psychology*. New York, NY: Wiley-Blackwell (2015).

14. Lehrer P, Kaur K, Sharma A, Shah K, Huseby R, Bhavsar J, et al. Heart rate variability biofeedback improves emotional and physical health and performance: a systematic review and meta-analysis. *Appl Psychophysiol Biofeedback.* (2020) 45:109–29.

15. Shaffer F, Ginsberg JP. An overview of heart rate variability metrics and norms. *Front Public Health.* (2017) 5:258. doi: 10.3389/fpubh.2017.00258

16. Arbo JE, Lessing JK, Ford WJH, Clark S, Finkelsztein E, Schenck EJ, et al. Heart rate variability measures for prediction of severity of illness and poor outcome in ED patients with sepsis. *Am J Emerg Med.* (2020) 38:2607–13.

17. Laborde S, Mosley E, Thayer JF. Heart rate variability and cardiac vagal tone in psychophysiological research - recommendations for experiment planning. data analysis, and data Reporting. *Front Psychol.* (2017) 8:213. doi: 10.3389/fpsyg.2017.00213

18. Porges SW. The polyvagal perspective. *Biol Psychol.* (2007) 74:116–43.

19. Balzarotti S, Biassoni F, Colombo B, Ciceri MR. Cardiac vagal control as a marker of emotion regulation in healthy adults: a review. *Biol Psychol.* (2017) 130:54–66. doi: 10.1016/j.biopsycho.2017.10.008

20. Borchini R, Veronesi G, Bonzini M, Gianfagna F, Dashi O, Ferrario MM. Heart rate variability frequency domain alterations among healthy nurses exposed to prolonged work stress. *Int J Environ Res Public Health.* (2018) 15:113. doi: 10.3390/ijerph15010113

21. Castaldo R, Montesinos L, Melillo P, James C, Pecchia L. Ultra-short term HRV features as surrogates of short term HRV: a case study on mental stress detection in real life. *BMC Med Inform Decis Mak.* (2019) 19:12. doi: 10.1186/s12911-019-0742-y

22. Escorihuela RM, Capdevila L, Castro JR, Zaragozà MC, Maurel S, Alegre J, et al. Reduced heart rate variability predicts fatigue severity in individuals with chronic fatigue syndrome/myalgic encephalomyelitis. *J Transl Med.* (2020) 18:1–12.

23. Huang M, Shah A, Su S, Goldberg J, Lampert RJ, Levantsevych OM, et al. Association of depressive symptoms and heart rate variability in vietnam war-era twins: a longitudinal twin difference study. *JAMA Psychiatry.* (2018) 75:705–12. doi: 10.1001/jamapsychiatry.2018.0747

24. Kircanski K, Williams LM, Gotlib IH. Heart rate variability as a biomarker of anxious depression response to antidepressant medication. *Depress Anxiety.* (2019) 36:63–71. doi: 10.1002/da.22843

25. Lee SM, Han H, Jang K, Huh S, Huh H, Joo J, et al. Heart rate variability associated with posttraumatic stress disorder in victims' families of sewol ferry disaster. *Psychiatry Res.* (2018) 259:277–82. doi: 10.1016/j.psychres.2017.08.062

26. Vasconcellos F, Seabra A, Cunha F, Montenegro R, Penha J, Bouskela E, et al. Health markers in obese adolescents improved by a 12-week recreational soccer program: a randomised controlled trial. *J Sports Sci.* (2016) 34:564–75. doi: 10.1080/02640414.2015.1064150

27. Busseri MA. Toward a resolution of the tripartite structure of subjective well-being. *J Personal.* (2015) 83:413–28. doi: 10.1111/jopy.12116

28. Joshanloo M, Pietromonaco PR. Investigating the relationships between subjective well-being and psychological well-being over two decades. *Emotion.* (2019) 19:183–7. doi: 10.1037/emo0000414

29. An E, Nolty AAT, Amano SS, Rizzo AA, Buckwalter JG, Rensberger J. Heart rate variability as an index of resilience. *Milit Med.* (2020) 185:363–9.

30. Bonanno GA. Loss, trauma, and human resilience: have we underestimated the human capacity to thrive after extremely aversive events? *Am Psychol.* (2004) 59:20–8. doi: 10.1037/0003-066X.59.1.20

31. Shaffer, F, McCraty R, Zerr CL. A healthy heart is not a metronome: an integrative review of the heart's anatomy and heart rate variability. *Front Psychol.* (2014) 5:1040. doi: 10.3389/fpsyg.2014.01040

32. Deakin University. *What data do I need to keep and how long?* (2022). Available online at: https://www.deakin.edu.au/library/research/manage-data/store/what-data-do-i-need-to-keep-and-for-how-long (accessed September 19, 2021).

33. Sun Q, Ng K-M, Wang C. A validation study on a new chinese version of the dispositional hope scale. *Meas Eval Couns Dev.* (2012) 45:133–48. doi: 10.1177/0748175611429011

34. Ishaque S, Khan N, Krishnan S. Trends in heart-rate variability signal analysis. *Front Digi Health.* (2021) 3:639444. doi: 10.3389/fdgth.2021.639444

35. Russoniello CV, Zhirnov YN, Pougatchev VI, Gribkov EN. Heart rate variability and biological age: implications for health and gaming. *Cyberpsychol Behav Soc Netw.* (2013) 16:302–8. doi: 10.1089/cyber.2013.1505

36. Baldwin AL. Case report: control of heart rate variability to cope with stress and pain after colectomy. *Biofeedback.* (2018) 46:60–4. doi: 10.5298/1081-5937-46.3.01

37. Dijkstra SM, Soer R, Bieleman A, McCraty R, Oosterveld F, Gross D, et al. Exploring a 1-minute paced deep-breathing measurement of heart rate variability as part of a workers' health assessment. *Appl Psychophysiol Biofeedback.* (2019) 44:83–96. doi: 10.1007/s10484-018-9422-4

38. Fung SC. Effect of a canine-assisted read aloud intervention on reading ability and physiological response: a pilot study. *Animals.* (2019) 9:474. doi: 10.3390/ani9080474

39. Lundstrom, TH, Rocheleau CA, Guerra DF, Erickson CA. Participation in a yoga study decreases stress and depression scores for incarcerated women. *Int J Yoga Ther.* (2021) 31:Article_6. doi: 10.17761/2021-D-19-00064

40. Sun S, Hu C, Pan J, Liu C, Huang M. Trait mindfulness is associated with the self-similarity of heart rate variability. *Front. Psychol.* (2019) 10:314. doi: 10.3389/fpsyg.2019.00314

41. Low A, McCraty R. Heart rate variability: new perspectives on assessment of stress and health risk at the workplace. *Heart Mind.* (2018) 2:16–27. doi: 10.4103/hm.hm_16_18

42. Clinical and Translational Science Institute. *Sample size calculators for designing clinical research.* (2021). Available online at: https://ctsi.ucsf.edu/ (accessed September 19, 2021).

43. Dekker JM, Crow RS, Folsom AR, Hannan PJ, Liao D, Swenne CA, et al. Low heart rate variability in a 2-minute rhythm strip predicts risk of coronary heart disease and mortality from several causes The ARIC Study. *Circulation.* (2000) 102:1239–44. doi: 10.1161/01.cir.102.11.1239

44. Fang SC, Wu YL, Tsai PS. Heart Rate variability and risk of all-cause death and cardiovascular events in patients with cardiovascular disease: a meta-analysis of cohort studies. *Biol Res Nurs.* (2019) 22:45–56.

45. Kemp AH, Quintana DS. The relationship between mental and physical health: insights from the study of heart rate variability. *Int J Psychophysiol.* (2013) 89:288–96. doi: 10.1016/j.ijpsycho.2013.06.018

46. Colangelo LA., Yano Y, Jacobs DR, Lloyd-Jones DM. (2020). Association of resting heart rate with blood pressure and incident hypertension over 30 years in black and white adults: the CARDIA study. *Hypertension.* 76, 692–98. doi: 10.1161/HYPERTENSIONAHA.120.15233

47. Griggs S. Hope and mental health in young adult college students: an integrative review. *J Psychosoc Nurs Ment Health Serv.* (2017) 55:28–35. doi: 10.3928/02793695-20170210-04

48. Segerstrom SC. Optimism and immunity: do positive thoughts always lead to positive effects? *Brain Behav Immun.* (2005) 19:195–200. doi: 10.1016/j.bbi.2004.08.003

49. Segerstrom SC, Castañeda JO, Spencer TE. Optimism effects on cellular immunity: testing the affective and persistence models. *Personal Ind Diff.* (2003) 35:1615–24. doi: 10.1016/S0191-8869(02)00384-7

50. Zhao SZ, Wong J, Luk TT, Wai A, Lam TH, Wang MP. Mental health crisis under COVID-19 pandemic in Hong Kong, China. *Int J Infect Dis.* (2020) 100:431–3. doi: 10.1016/j.ijid.2020.09.030

51. Marx RG, Menezes A, Horovitz L, Jones EC, Warren RF. (2003). A comparison of two time intervals for test-retest reliability of health status instruments. *J Clin Epidemiol.* 56, 730–5. doi: 10.1016/s0895-4356(03)00084-2

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COVID-19-related anxiety and the role of social media among Canadian youth

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Background: Current literature indicates that safety measures, including lockdowns during the COVID-19 pandemic, severely disrupted our lifestyle, marked by increased screen time. The increased screen time is mostly associated with exacerbated physical and mental wellbeing. However, the studies that examine the relationship between specific types of screen time and COVID-19-related anxiety among youth are limited.

Methods: We examined the usage of passive watching, social media, video games, and educational screen time and COVID-19-related anxiety at the 5-time points (Early-Spring 2021, Late-Spring 2021, Fall 2021, Winter 2022, and Spring 2022) among youth in Southern Ontario, Canada (N =117, mean age=16.82, male=22%, non-White=21%) and investigated the role of 4 types of screen time in COVID-19 related anxiety. COVID-related anxiety was measured using the Coronavirus Anxiety Scale (CAS). Descriptive statistics examined the binary relationships between demographic factors, screen time, and COVID-related anxiety. Also, partially adjusted and fully adjusted binary logistic regression analyses were conducted to examine the association between the types of screen time and COVID-19-related anxiety.

Results: During the late Spring of 2021, when the provincial safety restrictions were most stringent, screen time was the highest among the 5 data collection time points. Further, adolescents experienced the highest COVID-19-related anxiety during this period. On the other hand, young adults experienced the highest COVID-19-related anxiety during Spring 2022. In a partially adjusted model (accounting for other types of screen time), engaging in 1–5h per day on social media increased the likelihood of experiencing COVID-19-related anxiety compared to those who spend less than 1h per day (OR=3.50, 95%CI=1.14–10.72, p <0.05). Other types of screen time was not significantly associated with COVID-19-related anxiety. In a fully adjusted model (accounting for age, sex and ethnicity besides four types on screen time), 1–5h per day of social media remained significantly associated with COVID-19-related anxiety (OR=4.08, 95%CI=1.22–13.62, p <0.05).

Conclusion: Our findings suggest that COVID-19-related anxiety is associated with youth engagement in social media during the COVID-19 pandemic. Clinicians, parents, and educators should work collaboratively to provide developmentally appropriate approaches to reduce the negative social media impact on COVID-19-related anxiety and promote/foster resiliency in our community during the recovery period.

KEYWORDS

social media, screen time, COVID-19, youth, COVID-19-related anxiety

1. Introduction

The first case of COVID-19 was reported on January 23, 2020, in Ontario, Canada (1). The Ontario provincial government responded to various waves of the virus over the following 2 years by implementing public health measures. This included public health measures limiting individuals' contact, activities, and movement and the government-mandated closure of non-essential businesses, all indoor recreational programs, public libraries, theatres, and all outdoor recreational spaces, including parks and walking trails; and the transition from in-person learning to virtual education in grade schools (1–3). While some of these public health safety restrictions were lifted by June 22, 2020, ongoing changes to these restrictions have continued as there are still intense pressures on the healthcare system (e.g., backlogs from surgeries) (4, 5). As a result, people are still struggling with various mental health challenges, including COVID-19-related anxiety (i.e., dysfunctional anxiety associated with the COVID-19 crisis) (6, 7).

Current literature indicates that public health measures during the COVID-19 pandemic severely disrupted youth's lifestyle, marked by increased time spent in front of screens, including smartphones, TV, and computers (i.e., screen time), in particular, use of social media (8–12). For example, daily screen time doubled to over 5 hours during the pandemic compared to pre-pandemic usage levels among young adults in the US (10). Similarly, 30.8% of Canadian youth reported using social media for 5 or more hours daily during the pandemic (13). With the public safety measures in place, youth may have shifted their way of connecting using internet-based technologies, such as social media, as an alternative platform to play and socialize with friends and families (14). Staying socially and emotionally connected with peers and family through internet-based technology is important during the pandemic for social support and may alleviate feelings of loneliness and isolation (14, 15).

While screen time and social media platforms are one of the limited options for youth to connect during the pandemic, the increased social media screen time is associated with deterioration in many mental health domains among youth during the pandemic (8, 12, 16–20). For instance, a multi-national cross-sectional study (United States, United Kingdom, and Australia) on adolescents ($N = 3{,}810$) reported that frequent use of social media was associated with loneliness and a high level of emotional distress during the pandemic (21). Canadian adolescents also expressed concerns about the COVID-19 pandemic-related peer relationship and schooling issues (11). Notably, US (22) and Canadian adolescents (11) who spent more time on social media were associated with more COVID-19-related distress, loneliness and depression. Similarly, those exposed frequently to social media were positively associated with high odds of anxiety and a combination of depression and anxiety (16).

Given the possibility of continued screen time trends beyond the pandemic and extensive findings on the adverse impact on mental health, more research is warranted to clarify the role of screen time and social media on youth mental health. For example, studies investigating the role of specific types of screen time are limited. There is a potential overlap of screen time usage (e.g., one can multi-task texting and watching Netflix®), and the impact of each type of screen time on mental health may be different. Hence, it is crucial to delineate the role of different screen time types in mental health in the context of the pandemic. A recent study reported a stronger impact of active screen time (e.g., online games, social media) on psychosomatic complaints than passive screen time (e.g., watching TV) during the pandemic (20). However, further differentiation of screen time types commonly used during the pandemic, such as social media, online games, passively watching (e.g., Netflix®, T.V.), and education (e.g., online learning), is warranted. Furthermore, the role of screen time on COVID-19-specific anxiety is less investigated. As the pandemic is taking its course and safety measures are being adjusted based on its impact, it is important to understand how youth feel about the pandemic (e.g., COVID-19-related anxiety) and the factors associated with it to support them effectively.

In the current study, we examined the usage of passive watching, social media, video games, and educational screen time and COVID-19-related anxiety at five-time points (Early-Spring 2021, Late-Spring 2021, Fall 2021, Winter 2022, and Spring 2022) during the pandemic among youth in Southern Ontario, Canada. Further, we investigated the impact of the social media on COVID-19-related anxiety among Canadian youth during the pandemic. We hypothesized that the frequent use of social media would be associated with increased COVID-19-related anxiety among youth during the pandemic.

2. Methods

2.1. Procedure

This cross-sectional study is part of the study "Mindfulness and Social–Emotional Learning in Youth," examining the impact of a virtually-delivered mindfulness intervention on social–emotional competence in youths who engage in screen time. From April 2021 to April 2022, community youths were recruited from central- and north-central Ontario using digital flyers and word-of-mouth. The final sample ($N = 117$) used in this study consisted of the pre-survey of five cohorts (Early-Spring 2021, Late-Spring 2021, Fall 2021, Winter 2022, and Spring 2022), each recruited for up to 8-weeks. A complete pre-survey and informed consent were required for program participation (online mindfulness intervention). Informed consent and survey responses were collected using REDCap®, a secure online data repository system. The Institutional Research Ethics Board approved all components of this study (HPRA# 21.03.02).

2.2. Participants

All youth aged 18 to 25 will be invited to participate, with the exception of those who do not speak or understand English. The average participant age was 16.8 years old (SD 3.7; range 12–25), 67% of the participants were categorized as "adolescent" (12–17 years). In terms of ethnicity, 77% of participants were White, 8% were Asian, and 6% were First Nations or Metis. The sample was 78% female with 65% identifying as girl/woman (boy/man = 22%; other = 13%). Participants were recruited in central- and north-central Ontario (73% North Simcoe Muskoka region, 22% Guelph-Wellington, and 5% Haliburton region).

2.3. Measures

2.3.1. Demographics

Demographic information, including age, sex assigned at birth, and ethnicity were collected. Participant age, sex assigned at birth, and ethnicity were dichotomized as "adolescent" (12–17 years) or "young adult" (≥18 years), "male" or "female," and "White" or "Non-White (Asian, First Nations or Metis)" respectively.

2.3.2. Screen time

Participants were asked to report how many hours per day, on average, they dedicate to screen time across four types of usage (passive watching, social media, video games, and education). Passive screen time was defined as "[watching] TV, movies or videos, including YouTube® for pleasure"; social media as "[time spent] on social media (i.e., Facebook®, Instagram®, and Snapchat®, etc.)"; video games as, "[playing] video games (online and/or offline)"; and education as, "[use of] an electronic device (i.e., computer, laptop, tablet) for educational purposes (i.e., schooling)." Response choices for all four types of screen time were "less than 1 h," "1–3 h," "3–5 h," and "more than 5 h." Categories 1–3 h and 3–5 h were merged into one category based on the distribution of the responses in each category for the analysis.

2.3.3. Coronavirus anxiety scale

The Coronavirus Anxiety Scale (CAS) is a 5-item self-reported mental health screening tool designed to identify probable causes of dysfunctional anxiety associated with the COVID-19 crisis (6). Participants are asked to report on the frequency of specific experiences (i.e., "I felt dizzy, lightheaded, or faint when I read or listened to news about the coronavirus") over the preceding 2 weeks. The frequency of each item is rated on a 5-point Likert scale, and total scores range from 0 to 20. Based on the CAS score distribution in our sample (mean = 2.3; SD = 3.5), we dichotomized CAS scores ≤1 as "little to no COVID-19-related anxiety" and CAS > 1 as "some COVID-19-related anxiety." Independent studies of adults in US have demonstrated that the CAS is a reliable instrument (αs > 0.90), with solid factorial (single-factor; invariant across sociodemographic) and construct (correlated with anxiety, depression, suicidal ideation, and drug/alcohol coping) validity. A CAS total score ≥ 9 indicates probable dysfunctional coronavirus-related anxiety. Elevated scores on a particular item or a high total scale score (≥9) may indicate problematic symptoms for the individual that might warrant further assessment and/or treatment (6).

2.4. Analysis

Descriptive statistics were conducted to examine the binary relationships between demographic factors (i.e., age, sex, and ethnicity), screen time (i.e., passive watching, social media, education, and video games) and COVID-19-related anxiety. Also, partially adjusted and fully adjusted binary logistic regression analyses were conducted to examine the association between the types of screen time and COVID-19-related anxiety. All analyses were conducted using Software for Statistics and Data Science (STATA; version 16.0).

3. Results

Approximately half of the youth (47.9%, $N = 56$) used social media over 3 h per day during the pandemic. Slightly over half of the youth (61.5%, $N = 72$) youth of our sample spent over 3 h per day engaging in passive screen time. Most of our youth (82.6%, $N = 98$) spent over 3 h per day on the screens for educational purposes and spent the least time on video games (23.9%, $N = 28$). Table 1 presents COVID-19-related anxiety and screen time based on participant characteristics. Females tended to engage in more hours per day of passive, social media, and educational screen time but less videogame screen time, than males. White youth, on average, engaged in more passive and educational screen time than non-White youth. Young adults and adolescents reported similar screen time exposure, except for social media, which was higher among young adults.

In terms of COVID-19-related anxiety, average CAS scores were 2.3 (SD = 3.5), and 62% of youths reported little to no COVID-19-related anxiety (CAS ≤ 1). However, 11.4% of the youth in our sample had scores that met a clinically significant threshold of nine (6). Table 2 summarizes screen time and CAS scores across all five recruitment cohorts to understand better the impact of the evolving landscape of the COVID-19 pandemic. We observed an increase in CAS scores and educational screen time in Late-Spring 2021. Figure 1 shows an interaction of CAS scores with age groups across the recruitment cohort. Interestingly, young adult CAS scores were lower during the highly restrictive Late-Spring 2021 cohort but were considerably higher in our Spring 2022 cohort.

In a partially adjusted model (accounting for other types of screen time), 1–5 daily hours on social media was associated with increased odds of experiencing COVID-19-related anxiety compared to those who spend less than 1 h per day (OR = 3.50, 95% CI = 1.14–10.72, $p < 0.05$). Other types of screen time were not significantly associated with COVID-19-related anxiety. In a fully adjusted model (accounting for age, sex and ethnicity besides four types of screen time), 1–5 h of social media remained significantly associated with COVID-19-related anxiety (OR = 4.08, 95% CI = 1.22–13.62, $p < 0.05$). Although the positive direction of the association between social media >5 and CAS aligns with the association between 1–5 h and CAS, the association between social media >5 and CAS was not significant. Wide confidence intervals in regression models may indicate that the power to declare the differences is low and may lead to a type I error. We suspect that the relatively smaller sample size for social media >5 h ($N = 35$) than the 1–5 h ($N = 55$) may have limited this non-significant social media effect on CAS, as demonstrated in the wide 95% Confidence intervals in model 1 and 2 (M1: OR = 2.78, 95% CI = 0.77–10.05; M2: OR = 1.85, 95% CI = 0.46–7.44; see Table 3).

4. Discussion

We investigated the daily screen time usage and COVID-19-related anxiety during the pandemic among Canadian youth and probed the association between the four types of screen time and COVID-19-related anxiety. Most youths reported spending over 3 h per day on screens for pleasure (passive screen time and social media) and educational purposes during the pandemic. COVID-19-related anxiety was the highest during late spring 2021, and 11.4% of the participants reported experiencing a dysfunctional level of anxiety for COVID-19. Further, frequent social media use was positively associated with COVID-19-related anxiety.

Our findings align with the growing body of evidence suggesting heightened daily screen time use during the pandemic among youth (8–12), while less than 2 h of daily screen time for pleasure is

TABLE 1 COVID-19-related anxiety and screen time based on participant characteristics (*N*, %).

	Sex		Ethnicity		Age group	
	Female (*N* =87)	Male (*N* =24)	White (*N* =90)	Non-White (*N* =20)	Adolescent (*N* =78)	Young adult (*N* =39)
CAS (mean, SD)	2.5 (3.4)	1.7 (3.4)	2.4 (3.6)	2.1 (3.4)	2.0 (3.3)	3.0 (3.7)
Screen time						
Passive						
<1 h	3 (3%)	2 (8%)	5 (6%)	1 (5%)	4 (5%)	2 (5%)
1–5 h	49 (56%)	15 (63%)	48 (53%)	14 (70%)	45 (58%)	23 (59%)
>5 h	35 (40%)	7 (29%)	37 (41%)	5 (25%)	29 (37%)	14 (36%)
Social media						
<1 h	17 (20%)	10 (42%)	20 (22%)	7 (35%)	21 (27%)	6 (2%)
1–5 h	39 (45%)	11 (46%)	43 (48%)	6 (30%)	36 (46%)	19 (49%)
>5 h	31 (36%)	3 (13%)	27 (30%)	7 (35%)	21 (27%)	14 (36%)
Video games						
<1 h	46 (53%)	5 (21%)	40 (44%)	12 (60%)	33 (42%)	20 (51%)
1–5 h	34 (39%)	14 (58%)	40 (44%)	6 (30%)	35 (45%)	17 (44%)
>5 h	7 (8%)	5 (21%)	10 (12%)	2 (10%)	10 (13%)	2 (5%)
Education						
<1 h	9 (10%)	0 (0%)	6 (7%)	2 (10%)	7 (9%)	2 (5%)
1–5 h	26 (30%)	13 (54%)	28 (31%)	8 (40%)	27 (35%)	14 (36%)
>5 h	52 (60%)	11 (46%)	56 (62%)	10 (50%)	44 (56%)	23 (59%)

CAS, Coronavirus anxiety scale.

recommended by the Canadian 24 h movement guideline (23). Only 36.2% of post-secondary students (23) and 8% of children and adolescents (24) in Canada adhered to the Canadian 24 h movement guidelines for screen time. Most of our youths engaged in daily screen time over 3 h, exceeding the Canadian 24 h movement guidelines (23). Among them, 36.8% reported spending more than 5 hours daily on social media. Heightened daily screen time implicates lifestyle disruption, including decreased physical activity during the pandemic (10, 24).

Further, approximately one-third (38%) of youth reported experiencing some degree of COVID-19-related anxiety, and 11.4% of our sample had coronavirus-related anxiety scores that met a clinically significant threshold of nine, indicating a probable dysfunctional coronavirus-related anxiety (6). Our findings corroborate youth's pandemic-related concerns, such as their anxiety about the virus itself (e.g., fear of getting COVID-19, feeling unwell and unsafe) (17). The COVID-19-related anxiety was highest in late spring 2021 when provincial mandates were the most stringent. For instance, the provincial public health measure included school closure (April 19 to June 28, 2021) and a "stay-at-home" order (April 8 to June 2, 2021) that restricted all travel outside the house unless deemed essential (i.e., for work, to purchase groceries, for healthcare) during late spring 2021. Amidst these restrictions, only half of the eligible Ontarians between the ages of 12 and 17 had received their first COVID-19 vaccine, and less than 5% were fully vaccinated (received at least two COVID-19 vaccines). Given the circumstances during Late-Spring 2021, it is not surprising that we observed an increase in COVID-19-related anxiety, social media and educational screen time compared to the cohorts recruited prior to and after, Late-Spring 2021. Also, young adults showed heightened COVID-19-related anxiety than adolescents in Spring 2022. Speculatively, this age group contrast for COVID-19-related anxiety in Spring 2022 reflects the return to in-person learning for most post-secondary students in Ontario. For example, COVID-19-related policies/guidelines for post-secondary institutions were less harmonized, and many post-secondary students felt uncertain and were concerned about their health, mental health, and academic futures (25).

So far, this increase in screen time in youth, particularly when engaging with social media use during the pandemic (16, 18, 21), has been associated with poorer mental health outcomes (8, 12, 16–20). Our findings uniquely add to the literature by suggesting that accounting for other types of screen time and demographic information, spending 1–5 h daily on social media is associated with experiencing COVID-19-specific anxiety. A large volume of COVID-19-related topics is spread/shared on social media platforms, including misinformation from unreliable sources, creating "the COVID-19 social media infodemic" (26). Further, young people often recounted anxiety about COVID-19's impact on their wellbeing via social media (17). For example, a real-time, multi-platform online ethnography from March 2020 to March 2021 revealed that youth often commented on mental health difficulties arising from public safety measures and social disconnectedness and recounted their anxiety about the virus's impact on others (17). Further, although adolescents who feel lonely tended to use more social media during the pandemic, presumably to cope with the lack of social contact, it did not help them feel happier (27). We speculate that significant information sharing (from reliable and unreliable sources) related to the pandemic was found to have occurred on various social media platforms such as Twitter, Instagram, YouTube, Reddit, and Gab, escalating anxiety among social media users.

TABLE 2 Provincial restrictiveness, COVID-19 anxiety, and screen time usage according to recruitment cohort.

	2021			2022	
	Early-Spring (*N* =30)	Late-Spring (*N* =19)	Fall (*N* =15)	Winter (*N* =30)	Spring (*N* =20)
Variant of concern	Gamma	Gamma	Delta	Omicron	Omicron
School closures	No	Yes	No	Yes	No
Provincial lockdown	No	Yes	No	No	No
Masks mandatory	Yes	Yes	Yes	Yes	No
Received 1st vaccine[a]	11.3%	65.3%	75.5%	82.9%	84.5%
Received 2nd vaccine[a]	2.1%	19.4%	70.6%	77.5%	81.4%
Received 1st vaccine[b]	0%	51.9%	81.5%	87.3%	88.1%
Received 2nd vaccine[b]	0%	2.2%	71.9%	82.9%	84.3%
CAS	2.3 (3.9)	2.5 (3.1)	1.5 (2.0)	2.8 (4.1)	2.0 (3.5)
Screen time					
Passive					
<1 h	0 (0%)	2 (10%)	1 (7%)	1 (3%)	2 (10%)
1–5 h	19 (63%)	11 (55%)	9 (60%)	21 (66%)	8 (40%)
>5 h	11 (37%)	7 (35%)	5 (33%)	10 (31%)	10 (50%)
Social media					
<1 h	10 (33%)	4 (20%)	4 (27%)	5 (16%)	4 (20%)
1–5 h	15 (50%)	7 (35%)	5 (33%)	20 (63%)	8 (40%)
>5 h	5 (17%)	9 (45%)	6 (40%)	7 (22%)	8 (40%)
Video games					
<1 h	15 (50%)	11 (55%)	8 (53%)	10 (31%)	9 (45%)
1–5 h	12 (40%)	8 (40%)	7 (47%)	16 (50%)	9 (45%)
>5 h	3 (10%)	1 (5%)	0 (0%)	6 (19%)	2 (10%)
Education					
<1 h	3 (10%)	0 (0%)	3 (20%)	2 (6%)	1 (5%)
1–5 h	12 (40%)	6 (30%)	4 (27%)	12 (38%)	7 (35%)
>5 h	15 (50%)	14 (70%)	8 (53%)	18 (56%)	12 (60%)

Source: https://health-infobase.canada.ca/covid-19/vaccination-coverage/.
CAS, Coronavirus anxiety scale. [a]Adults > 17.
[b]Adolescents age 12–17.

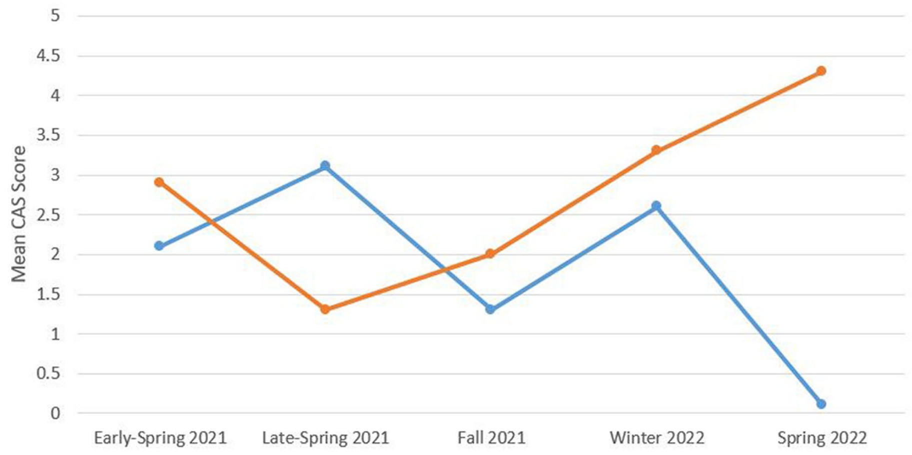

FIGURE 1
Adolescent (blue) and young adult (orange) mean CAS scores across the recruitment cohort. CAS, Coronavirus anxiety scale.

TABLE 3 Associations between screen time and participant characteristics and COVID-19-related anxiety (Odds ratio, 95% CI).

	Partially adjusted model (Model 1)	Fully adjusted model (Model 2)
Screen time		
Passive		
<1 h	ref	ref
1–5 h	0.66 (0.92–4.71)	0.44 (0.03–5.77)
>5 h	0.47 (0.06–3.42)	0.17 (0.01–2.26)
Social media		
<1 h	ref	ref
1–5 h	3.50 (1.14–10.72)*	4.08 (1.22–13.62)*
>5 h	2.78 (0.77–10.05)	1.85 (0.46–7.44)
Education		
<1 h	ref	ref
1–5 h	2.00 (0.25–16.11)	2.15 (0.24–19.45)
>5 h	1.21 (0.17–8.74)	1.55 (0.19–12.62)
Video game		
<1 h	ref	ref
1–5 h	0.48 (0.20–1.15)	0.45 (0.16–1.22)
>5 h	0.71 (0.17–2.89)	0.94 (0.20–4.51)
Age		
Adolescent (12–17 yrs. old)		ref
Young adult (18–24 yrs. old)		2.40 (0.82–7.01)
Sex		
Female		ref
Male		0.42 (0.12–1.52)
Ethnicity		
White		ref
Non-white		1.01 (0.32–3.25)

* <0.05; Confounding variables: Age, sex, and ethnicity.

Given this evidence, a growing need exists to consider different strategies to promote healthy screen hygiene in youth, particularly on social media during the pandemic and beyond.

Firstly, evidenced-based strategies have been reported that promote healthy social media screen time for youth to mitigate mental health harm, such as increased COVID-19 anxiety. The Canadian 24-Hour Movement Guidelines for Children and Youth recommend no more than 2 h per day of recreational screen time (23). To limit the negative impact of social media screen time, parents and caregivers may promote healthy social media screen use, encourage screen-free time, and limit anxiety-provoking content such as excessive pandemic coverage. Parents and caregivers can also be encouraged to model healthy social media screen hygiene by limiting their social media screen time (28). Guidance and support may be required to assist parents and caregivers in supporting youth to limit social media screen time through educational, public health, or health promotion campaigns (29).

Secondly, while parents and caregivers play an important role, they cannot be expected to address social media screen time increases alone. As such, a broader policy response may be warranted. Prior to the pandemic, youth remained connected with their peers through various activities such as in-person schooling, extracurricular programming, and online through various social media platforms. Due to public health restrictions, social media has allowed youth to stay connected to friends and family, especially when school and recreational facilities were closed (29). However, prolonged and excessive social media screen time use has also been linked to negative mental health outcomes (16, 18, 21). Prioritizing in-person schooling and extracurricular programming by ensuring a safe environment that supports uninterrupted full-time learning for youth may reduce social media screen time and endorse healthy behaviours at an important developmental stage.

Lastly, it is warranted to invest in resources and training opportunities to encourage youth to reflect on social media screen use and its impact on their mental health. Providing training, tools and strategies to navigate the online environment safely may promote healthy youth development (28, 30). This could include providing training on screen hygiene and social media screen time safety skills within an educational setting, which may be an effective strategy to reach a broad range of youth regardless of demographic and household factors.

There are several limitations to this current study. The cross-sectional design precludes our ability to understand the temporal ordering between screen time and COVID-19-related anxiety. Also, the sample size ($N = 117$) is modest for the number of variables we included in our regression models (model 1 = 4, model 2 = 7). We followed the rule of thumb to have at least 10 observations per predictor (31). To prove that the sample size ($N = 117$) is appropriate for the regression analysis we conducted to determine the impact of social media on COVID-related anxiety, we used SPSS Version 28 Power Analysis to estimate the N needed to detect a small effect (0.20) in regressions with $\alpha = 0.05$, power = 0.8, and 7 total number of predictors (4 test predictor), which returned an estimated N of 65. However, wide Confidence Intervals in regression models may indicate that the power to declare the differences is low, leading to a type I error. Replicating the findings with a larger sample, with proportionate number of participants for age, gender and ethnicity, using a longitudinal study design is warranted to further determine the relationship between screen time and COVID-19-related anxiety. Lastly, future studies should include more detailed demographic information of the sample, such as income level, occupation, and education to better characterize the sample and its links to screen time and COVID-related anxiety.

5. Conclusion

To our knowledge, this is the first study that explored the role of four screen time types (passive watching, social media, online games, and education) in COVID-19-related anxiety among Canadian youth. Based on our findings, COVID-19-related anxiety was the highest during late spring 2021, during the third wave of the COVID-19 pandemic when provincial mandates were the most stringent. At that time, 11.4% of the participants reported experiencing a dysfunctional level of anxiety for COVID-19. Further, frequent social media use was positively associated with COVID-19-related anxiety. Knowledge gained from this study will guide clinicians, parents, and educators to work collaboratively to provide developmentally appropriate approaches to reduce the negative social media impact on COVID-19-related anxiety among youth as our society recovers from the pandemic.

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 Waypoint Centre for Mental Health Care Research Ethics Board (HPRA# 21.03.02). All participants provided their written informed consent to participate in this study and legal guardians were informed of their participation.

Author contributions

All authors provided critical reviews, contributed to the final manuscript 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

References

1. Ontario Agency for Health Protection and Promotion (Public Health Ontario). *Enhanced epidemiological summary: COVID-19 in Ontario: a summary of wave 1*. ON: Queen's Printer for Ontario. (2020).

2. Desson Z, Weller E, McMeekin P, Ammi M. An analysis of the policy responses to the COVID-19 pandemic in France, Belgium, and Canada. *Health Policy Technol* (2020) 9:430–46. doi: 10.1016/j.hlpt.2020.09.002

3. Detsky AS, Bogoch II. COVID-19 in Canada: experience and response. *JAMA* (2020) 324:743–4. doi: 10.1001/jama.2020.14033

4. Ljungqvist O, Nelson G, Demartines N. The post COVID-19 surgical backlog: now is the time to implement enhanced recovery after surgery (ERAS). *World J Surg* (2020) 44:3197–8. doi: 10.1007/s00268-020-05734-5

5. Androutsou L, Latsou D, Geitona M. Health systems' challenges and responses for recovery in the pre and post COVID-19 era. *J Serv Sci Manag* (2021) 14:444–60. doi: 10.4236/jssm.2021.144028

6. Lee SA. Coronavirus anxiety scale: a brief mental health screener for COVID-19 related anxiety. *Death Stud* (2020) 44:393–401. doi: 10.1080/07481187.2020.1748481

7. Shevlin M, McBride O, Murphy J, Miller JG, Hartman TK, Levita L, et al. Anxiety, depression, traumatic stress and COVID-19-related anxiety in the UK general population during the COVID-19 pandemic. *BJPsych Open* (2020) 6:e125. doi: 10.1192/bjo.2020.109

8. Tandon PS, Zhou C, Johnson AM, Gonzalez ES, Kroshus E. Association of children's physical activity and screen time with mental health during the COVID-19 pandemic. *JAMA Netw Open* (2021) 4:e2127892. doi: 10.1001/jamanetworkopen.2021.27892

9. Schmidt SC, Anedda B, Burchartz A, Eichsteller A, Kolb S, Nigg C, et al. Physical activity and screen time of children and adolescents before and during the COVID-19 lockdown in Germany: a natural experiment. *Sci Rep* (2020) 10:1–12. doi: 10.1038/s41598-020-78438-4

10. Giuntella O, Hyde K, Saccardo S, Sadoff S. Lifestyle and mental health disruptions during COVID-19. *Proc Natl Acad Sci* (2021) 118:e2016632118. doi: 10.1073/pnas.2016632118

11. Ellis WE, Dumas TM, Forbes LM. Physically isolated but socially connected: psychological adjustment and stress among adolescents during the initial COVID-19 crisis. *Can J Behav Sci/Revue canadienne des sciences du comportement* (2020) 52:177–87. doi: 10.1037/cbs0000215

12. Muzi S, Sansò A, Pace CS. What's happened to Italian adolescents during the COVID-19 pandemic? A preliminary study on symptoms, problematic social media usage, and attachment: relationships and differences with pre-pandemic peers. *Front Psych* (2021) 12:12. doi: 10.3389/fpsyt.2021.590543

13. Boak A, Elton-Marshall T, Hamilton HA. The wellbeing of Ontario students: findings from the 2021 Ontario student drug use and health survey Ontario, Canada: Centre for Addiction & Mental Health (CAMH) (2022). Report No.: ISBN: 978-1-77114-396-7.

14. Saltzman LY, Hansel TC, Bordnick PS. Loneliness, isolation, and social support factors in post-COVID-19 mental health. *Psychol Trauma Theory Res Pract Policy* (2020) 12:S55–7. doi: 10.1037/tra0000703

15. Nagata JM, Magid HSA, Gabriel KP. Screen time for children and adolescents during the coronavirus disease 2019 pandemic. *Obesity* (2020) 28:1582–3. doi: 10.1002/oby.22917

16. Gao J, Zheng P, Jia Y, Chen H, Mao Y, Chen S, et al. Mental health problems and social media exposure during COVID-19 outbreak. *PLoS One* (2020) 15:e0231924. doi: 10.1371/journal.pone.0231924

17. Winter R, Lavis A. The impact of COVID-19 on young People's mental health in the UK: key insights from social media using online ethnography. *Int J Environ Res Public Health* (2021) 19:352. doi: 10.3390/ijerph19010352

18. Pandya A, Lodha P. Social connectedness, excessive screen time during COVID-19 and mental health: a review of current evidence. *Front Hum Dyn* (2021) 3:45. doi: 10.3389/fhumd.2021.684137

19. Cost KT, Crosbie J, Anagnostou E, Birken CS, Charach A, Monga S, et al. Mostly worse, occasionally better: impact of COVID-19 pandemic on the mental health of Canadian children and adolescents. *Eur Child Adolesc Psychiatry* (2022) 31:671–84. doi: 10.1007/s00787-021-01744-3

20. Khan A, Lee E-Y, Janssen I, Tremblay MS. Associations of passive and active screen time with psychosomatic complaints of adolescents. *Am J Prev Med* (2022) 63:24–32. doi: 10.1016/j.amepre.2022.01.008

21. Geirdal AØ, Ruffolo M, Leung J, Thygesen H, Price D, Bonsaksen T, et al. Mental health, quality of life, wellbeing, loneliness and use of social media in a time of social distancing during the COVID-19 outbreak. A cross-country comparative study. *J Ment Health* (2021) 30:148–55. doi: 10.1080/09638237.2021.1875413

22. Meyer J, McDowell C, Lansing J, Brower C, Smith L, Tully M, et al. Changes in physical activity and sedentary behavior in response to COVID-19 and their associations with mental health in 3052 US adults. *Int J Environ Res Public Health* (2020) 17:6469. doi: 10.3390/ijerph17186469

23. Tremblay MS, Carson V, Chaput J-P, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab* (2016) 41:S311–27. doi: 10.1139/apnm-2016-0151

24. Xiang M, Zhang Z, Kuwahara K. Impact of COVID-19 pandemic on children and adolescents' lifestyle behavior larger than expected. *Prog Cardiovasc Dis* (2020) 63:531–2. doi: 10.1016/j.pcad.2020.04.013

25. Patterson ZR, Gabrys RL, Prowse RK, Abizaid AB, Hellemans KG, McQuaid RJ. The influence of COVID-19 on stress, substance use, and mental health among postsecondary students. *Emerg Adulthood* (2021) 9:516–30. doi: 10.1177/21676968211014080

26. Cinelli M, Quattrociocchi W, Galeazzi A, Valensise CM, Brugnoli E, Schmidt AL, et al. The COVID-19 social media infodemic. *Sci Rep* (2020) 10:1–10. doi: 10.1038/s41598-020-73510-5

27. Cauberghe V, Van Wesenbeeck I, De Jans S, Hudders L, Ponnet K. How adolescents use social media to cope with feelings of loneliness and anxiety during COVID-19 lockdown. *Cyberpsychol Behav Soc Netw* (2021) 24:250–7. doi: 10.1089/cyber.2020.0478

28. Vanderloo LM, Carsley S, Aglipay M, Cost KT, Maguire J, Birken CS. Applying harm reduction principles to address screen time in young children amidst the COVID-19 pandemic. *J Dev Behav Pediatr* (2020) 41:335–6. doi: 10.1097/DBP.0000000000000825

29. Amran MS, Jamaluddin KA. Adolescent screen time associated with risk factor of fear of missing out during pandemic Covid-19. *Cyberpsychol Behav Soc Netw* (2022) 25:398–403. doi: 10.1089/cyber.2021.0308

30. Moreno MA, Whitehill JM. New media, old risks: toward an understanding of the relationships between online and offline health behavior. *Arch Pediatr Adolesc Med* (2012) 166:868–9. doi: 10.1001/archpediatrics.2012.1320

31. Katz MH. *Multivariable analysis: a practical guide for clinicians and public health researchers*. Cambridge: Cambridge university press (2011).

Appendix

Table A1 COVID-19-related anxiety (average CAS score) for passive, social media, video games, and education screen time (<1h, 1–4h, >5h per day) in five-time points (Early-Spring 2021, Late-Spring 2021, Fall 2022, Winter 2022, and Spring 2022).

	2021			2022	
	Early-Spring (*N* =30)	Late-Spring (*N* =19)	Fall (*N* =15)	Winter (*N* =30)	Spring (*N* =20)
Passive	% (CAS)				
<1 h	0%	10% (2.50)	7% (0.00)	3% (1.00)	10% (4.50)
1–5 h	63% (2.58)	55% (2.18)	60% (2.22)	66% (3.58)	40% (2.50)
>5 h	37% (1.82)	35% (3.17)	33% (0.40)	31% (1.60)	50% (1.10)
Social media					
<1 h	33% (1.40)	20% (3.46)	27% (1.25)	16% (2.80)	20% (0.00)
1–5 h	50% (2.13)	35% (3.93)	33% (2.00)	63% (3.39)	40% (2.50)
>5 h	17% (4.60)	45% (2.28)	40% (1.17)	22% (1.43)	40% (2.50)
Video games					
<1 h	50% (2.33)	55% (3.34)	53% (2.50)	31% (3.10)	45% (2.33)
1–5 h	40% (1.80)	40% (2.71)	47% (0.29)	50% (2.50)	45% (2.11)
>5 h	10% (4.33)	5% (0.00)	0%	19% (3.17)	10% (0.00)
Education					
<1 h	10% (0.33)	0% (2.00)	20% (1.67)	6% (0.00)	5% (3.00)
1–5 h	40% (2.17)	30% (2.77)	27% (2.75)	38% (2.60)	35% (1.29)
>5 h	50% (2.80)	70% (2.53)	53% (0.75)	56% (3.28)	60% (2.33)

CAS, Coronavirus anxiety scale.

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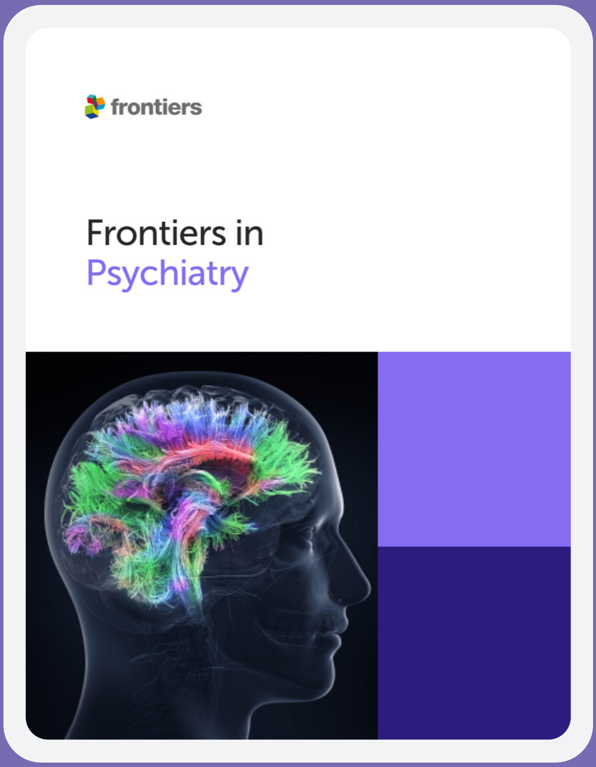

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