LARC Mental health summit: Suicide prevention

Edited by
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LARC Mental health summit: Suicide prevention

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Table of
contents

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Editorial: LARC mental health summit: Suicide prevention

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Editorial on the Research Topic
LARC mental health summit: Suicide prevention

This Research Topic of Frontiers in Psychiatry was developed by scientists and clinicians within the Louisiana Addiction Research Center (LARC). The LARC is one of six research centers at Louisiana State University Health Shreveport (LSUHS). LSUHS includes the School of Medicine, School of Graduate Studies, and School of Allied Health. The campus is attached to a large level-1 trauma center and safety-net hospital that serves the vulnerable communities of North Louisiana, East Texas, South Arkansas, and elsewhere. It is one of only 120 academic medical centers in the United States.

The mission of the LARC is to provide addiction research and education in an integrated environment pursuing the latest in innovative approaches and learning. Through this research it is our goal to develop therapeutic models that optimize compassionate care to patients suffering from substance use disorders (SUDs), while improving knowledge and understanding of SUDs as a public health issue through active collaboration with our community. This LARC is also focused on understanding the interaction between SUDs and critical comorbid conditions such as depression and anxiety that may contribute to drug taking. It places great emphasis on understanding how the interactions between these comorbidities and drug taking can lead to the devastating outcomes of fatal drug overdoses and suicide.

The emergence of the SARS-CoV-2/COVID-19 pandemic created a public health crisis of unprecedented magnitude. The leadership of the LARC wrote from early in the pandemic that the stress, economic insecurity, and breakdown in social support were likely to lead to or exacerbate ongoing mental and behavioral health crises, with dramatic increases in depression, anxiety, substance use, drug-related overdoses, and suicide. To combat these crises locally, the LARC organized a Mental Health Summit in Shreveport, Louisiana. Participants included local physicians and allied health clinicians, LSUHS medical residents and students, LSUHS scientists and Ph.D. graduate students, LSUHS allied health professionals and students, and LSUHS physician alumni. The goals of the

summit were to educate and train scientists, providers and our community about SUDs and suicide.

In our role as a component of an academic medical center, the LARC targeted this summit to practicing and trainee scientists and clinicians, and it used an evidenced-based approach. According to the Centers for Disease Control and Prevention, during the pandemic, younger adults, adolescents, racial/ethnic minorities, and essential workers (including frontline healthcare workers) showed disproportionately worse mental health outcomes, increased substance use, and elevated suicidal ideation compared to the general population. Front-line healthcare (essential) workers were faced with shortages of protective equipment, working for long hours, fear for their lives and their families, and social isolation. Over 20% of essential workers reported seriously considering suicide during the pandemic. Adolescents and young adults were faced with disruptions of social connections during key developmental periods, disruption of their school schedule, and the breakdown in contact with friends, and over 25% reported significant suicidal ideation. Practicing psychiatrists and emergency physicians were dealing with this crisis in younger adults and essential workers with limited data with which to make evidence-based decisions, particularly as it relates to effective interventions that can be implemented while routine clinical care was hampered during the pandemic.

This Research Topic was built out of the research that was discussed during that summit. The summit was designed to understand and address the mental health consequences of the COVID-19 pandemic, particularly as it relates to stress, social isolation and substance use. The submissions discuss data on an international level, including the articles entitled "*Quality and Quantity of Serious Violent Suicide Attempts during the COVID-19 Pandemic* (Maleitzke et al.)," and "*Trends in Online Searching Toward Suicide Pre, During, and Post the First Wave of COVID-19 Outbreak in China* (Chen et al.)." The article entitled the "*Catalytic Reaction Model of Suicide* (McPherson et al.)" provides a theoretical framework for understanding suicide and the article "*Impulsiveness Indirectly Affects Suicidal Ideation Through Depression and Simultaneously Moderates the Indirect Effect: A Moderated Mediation Path Model* (Zhang et al.)" documents a domain that extensively overlaps between suicide and SUDs.

The Research Topic provides proactive tools for individuals and clinicians to use to protect adolescents, young adults, essential workers, women, underserved communities, and others from suicide and other adverse mental health outcomes. Given the social isolation necessitated by the pandemic, a major component of this was a focus on the impacts of social media use. The articles "*Social Media Use and Body Image Issues Among Adolescents in a Vulnerable Louisiana Community* (Sagrera et al.)," "*Teen Advisory Council Survey Factors Associated with Self-Harming Thoughts* (McPherson et al.)," "*Concern on Cyber Violence and Suicide during COVID-19 Pandemic* (Liu et al.)," provide detailed analyses in this regard. The Research Topic also provides strategies for protecting mental health and preventing suicide, particularly in the article "*Wesley LifeForce Suicide Prevention Gatekeeper Training in Australia: Six Month Follow-up Evaluation of Full and Half Day Community* Programs (Hawgood et al.)" and the article "*Promoting Student Wellness and Self-Care during COVID 19: The Role of Institutional Wellness* (Vazquez Morgan)." These articles also touch on strategies that can be implemented during social distancing.

The leaders of the LARC stand with individuals facing mental and behavioral health challenges. Our service and our hearts are with you. We are committed to individuals and communities that experience neglect and adverse experiences. We work every day to foster collaborative multidisciplinary translational research projects that propel new advances in science toward new treatments for mental and behavioral health. We engage our community of stakeholders throughout Louisiana and nationally/internationally to provide outreach and education on the science of addiction and the new advances in care that are emerging. We are driving innovations in the current models of care to allow for the integration of these new advances, with the goals of decreased relapse and readmission rates, decreased emergency psychiatry utilization, and increased resilience and wellbeing. It is our hope that this Research Topic can be of utility to the international scientific and medical communities as they progress toward these goals.

Author contributions

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

Conflict of interest

Publisher's note

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Wesley LifeForce Suicide Prevention Gatekeeper Training in Australia: 6 Month Follow-Up Evaluation of Full and Half Day Community Programs

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Background and Objective: Wesley Mission LifeForce training is an Australian suicide prevention gatekeeper program which has not been formally evaluated. The aims of this evaluation were to (1) determine the short- and medium- term impacts of the training on worker capabilities (perceived and declarative knowledge), attitudes, and reluctance to intervene measures; and (2) compare the impact of the half and full day workshops on these measures.

Method: 1,079 Australian community workers of diverse professional backgrounds completed a pre-workshop questionnaire as part of registration for the Wesley LifeForce suicide prevention training between 2017 and 2019. Of these, 299 participants also completed the post workshop questionnaires (matched sample). They attended either half day ($n = 97$) or full day workshops (n = 202) and completed also a 3- and 6- month follow-up questionnaire. We used linear mixed-effect modeling for repeated measures to analyze data.

Results: LifeForce training participants experienced an increase in perceived capability, declarative knowledge, more positive attitudes and reduced reluctance to intervene, at least in the short term. The program is particularly well targeted for community gatekeepers with no prior training, albeit those with prior training in this study also experienced positive and significant gains on most measured constructs.

Conclusions: We found evidence of effectiveness of the Wesley LifeForce training over time, without difference between the short (half day) and longer (full day) formats of delivery. Nevertheless, the latter format offers skills-based and skills rehearsal opportunities, the impacts of which we were unable to measure in this evaluation and should be estimated in the future.

Keywords: suicide, suicide prevention, gatekeeper training, Wesley LifeForce, capability, evaluation

INTRODUCTION

There are several definitions of gatekeeper (GK), a concept that has evolved over time from being simply "a person to whom troubled people are turning for help" (1, p. 39) to those in a position to recognize a crisis and the warning signs that someone may be contemplating suicide (1), or a community member who has some face to face contact with numerous community members as part of their standard role (and who may be trained to identify at risk persons and refer them to appropriate support services) (2). The role of GK can be informally denoted, such as parents, friends, neighbors, sports coach or, formally designated such as teachers, doctors, nurses, police officers, and others who may, as a function of their work role, come into contact with suicidal persons (3).

There is some evidence for gatekeeper training (GKT) as a promising suicide prevention initiative (4), For example, GKT has been found to increase perceived knowledge and declarative knowledge about suicide (5–7); enhance self-efficacy for intervening (8, 9); reduce reluctance to intervene (10, 11); reduce stigma associated with suicide (12) and improve attitudes toward suicide/suicide prevention (13). However, while there is some evidence for the short-term efficacy of GKT, there is less evidence for long-term effects of constructs other than knowledge and self-efficacy (14). Interestingly, there is no evidence for retention of attitudinal change over time (14), which, according to Burnette et al. (15), represents a particularly critical outcome for GTK.

The Wesley LifeForce community suicide prevention training program is part of Wesley Mission's national suicide prevention program, funded by the Commonwealth Department of Health as part of Australia's National Suicide Prevention Strategy. The three main activities of Wesley LifeForce include: a) Suicide Prevention Training, b) Suicide Prevention Networks, and c) Memorial Services. The first of these, Wesley LifeForce Suicide Prevention Training, was the focus of the current evaluation.

GKT programs, such as Wesley LifeForce training, aim at educating volunteers or designated individuals in the community to be able to identify people who may be at-risk of suicide. They are designed specifically to enhance knowledge, attitudes, and skills of the GK in order to enable competency to identify those at risk, determine appropriate action for optimal safety of the person, and make appropriate referrals as necessary (15).

Evaluation of Wesley LifeForce training included Phase 1—review of the appropriateness of the training in terms of alignment with minimum training competencies in content and structure; and Phase 2—evaluation of the short to medium term impacts of the training on GK knowledge, attitudes and skills. Phase 1 evaluation findings can be reviewed in a separate report provided to Wesley Mission (see 2). In brief, the evaluation found that the Wesley LifeForce training complied with nearly all minimum standards and competencies for GKT as defined in the study. Recommendations were made for minor improvement of content-related competencies (associated with key learning outcomes of the program) and more significant modifications to the delivery/structural competencies of the training. All recommendations were subsequently implemented. The current

study presents Phase 2 findings of the Wesley LifeForce Suicide Prevention Training Evaluation (an updated edition following implementation of the recommended changes).

The Wesley LifeForce training package was designed to meet the needs of both informal and formal GKs, with the former addressed by community training and the latter via more targeted specialized training (e.g., for aged care nurses and relationship counselors). The aim of the current paper is to evaluate the effects of Wesley LifeForce suicide prevention training program targeted at informal GKs (the general community). Specifically, we aimed to compare and determine impacts of the half day and full day general community training programs on perceptions of capability, declarative knowledge, attitudes toward suicide prevention and reluctance to intervene from before to after training, and at three and six-month follow-up periods.

METHOD

Intervention

The general community training's target audience are persons with moderate to no suicide prevention training and/or those requiring contemporary refresher training. LifeForce community workshops are offered as half day (4 h) or full day (6 h) options, with the latter including more skills-based learning mechanisms using video and role-play activities. The training goals for community training include: Identify people who may be at risk of suicide; Communicate appropriately with a suicidal person; Ask a person if they are considering suicide; Conduct a suicide intervention. Three sessions are covered in the training: Session 1 covers the scope of suicide in Australia (statistics, terminology, definitions, theoretical models); Session 2 examines personal/professional beliefs and attitudes as well as barriers to suicide prevention; and, risk and protective factors, and warning signs and 'triggers' for suicidality/suicide; and Session 3 bridges understanding to skills-based responses using the S.A.L.T (See, Ask, Listen, and Take the person to help) intervention model to guide knowledge application. This intervention model is unique to Wesley LifeForce training, and therefore any gains in measures of declarative knowledge testing this specific model of intervention is less likely to have been gained from general exposure to suicide prevention education or awareness.

Study Design and Data Collection

Recruitment of participants to the training was via the Wesley Mission website and related news articles and online community networks' newsletter. More specifically areas of high suicide rate around the country were identified and local organizations were approached to reach local networks. Training is hosted at multiple local community venues within each jurisdiction of Australia (all states and territories), with offerings of community training occurring roughly 4 times per month nationally. Participant numbers at workshops were 10–20 per delivery.

A prospective study design was used, with online questionnaires distributed at four time-points to all community training participants. Registration required completion of the pre-workshop online questionnaire, while responding to the subsequent questionnaires relied on participants' willingness to

continue participation in the study, which ran from January 2017 until December 2019. The post-workshop questionnaire was sent soon after the workshop, and the follow-up questionnaires were emailed to attendees at 3- and 6–months after the workshops. Two reminders were sent to participants within 2–3 weeks of each wave of the study. The attrition rates were 72.3% from pre- to post-, 72.9% from post to 3-month follow-up, and 44.4% from 3- to 6-month follow-up. All procedures were approved by the Griffith University Human Research Ethics Committee (2017/241).

Concerning professional background of participants, 30% were medical doctors, 29% were psychologists, 10% were epidemiologists, and 31% were from 'other' professions (e.g., social worker, student, sociologist, public health professional, teacher, counselor/psychotherapist, analyst, CEO, or pastor).

Measures

Background information included participants' age, gender, Indigenous status, Culturally and Linguistically Diverse background (CALD), professional role, work status, education, years in suicide prevention role, prior training, and expectation of using training in future.

Outcome measures included reluctance to intervene, perceived capability in suicide prevention, declarative knowledge about LifeForce training learning outcomes, and attitudes toward suicide and suicide prevention. The specific measures were as follows:

Reluctance to Intervene is a 9-item scale measuring reluctance to intervene with a suicidal individual (10). Participants rated their level of agreement on a 5-point Likert scale from "strongly disagree" to "strongly agree," with two items reverse-scored. Each item value is summed for a total score ranging from 9 to 45 where higher values mean less reluctance. This scale had poor internal consistency ($\alpha = 0.45$) as compared to the original testing results by the authors of the scale ($\alpha = 0.68$) (10).

Perceived Capability Scale is a 15-item scale measuring perceived suicide prevention capabilities on skills and/or knowledge items that may be relevant when acting as a 'gatekeeper' and assisting someone at risk of suicide, and which are covered in the LifeForce training content (16). Participants are asked to rate their current level of capability on a 5-point Likert scale ranging from "not at all capable" to "highly capable." A total score ranged from 15 to 75, where higher scores mean higher capability. This scale presented an excellent internal consistency ($\alpha = 0.95$).

Declarative Knowledge Scale was developed to align with the LifeForce learning objectives and outcomes of all training modules (16). It includes 17-items in True/False/Do not know answer format. Correct answers to these questions were ascertained by referring to the workshop training material developed by Wesley Mission. Score equals the percentage of correct answers. This scale showed a good internal consistency ($\alpha = 0.73$).

Attitudes to Suicide Prevention scale (ASP) is a 14-item self-report scale measuring attitudes toward suicide and suicide prevention (17). Thirteen items use a Likert scale from "strongly agree" to "strongly disagree" and the final item response ranging from "none" to "all." The responses to these items are scored from one (strongly disagree/none) to five (strongly agree/all) and summed, resulting in a total score ranging from 14 to 70, with higher scores indicating more negative attitudes. This scale had a poor internal consistency ($\alpha = 0.47$) as compared to the original testing results by the authors of the scale ($\alpha = 0.77$) (17).

Statistical Analysis

The outcome measures presented above were used as dependent variables. All scales had a normal distribution (the range for skewness or kurtosis between +1.5 and −1.5). We used linear mixed-effect modeling for repeated measures, which accounts for the correlation between the repeated measures for each individual (18). Moreover, this method also deals with unbalanced data with the assumption that missing data are missing at random and they are not dropped from the analyses.

For the linear mixed-effect regression models, workshop type (full day and half day), time (pre, post, 3- and 6-month follow-up), age group (<35 years; 35+ years), working in suicide prevention (never, 0–12 months, 1–5 years, 5–10 years, 10+ years), gender (male, female, other gender identity), work discipline (community support, health, other), and the workshop type × time interaction, and group were entered as fixed effects. The participant ID variable was included in the random intercept to model for within-person factors at baseline. To reduce multicollinearity, all variables included as fixed effects were centered (19). Time (pre, post, 3-month, and 6-month follow-up) was included as a repeated effect. A First-Order Autoregressive (AR1) and Unstructured (UN) covariance structures were examined using −2 Res Log Likelihood and Akaike's information criterion (AIC). Both structures were applied to the levels of group (workshop group) ∗person (as workshops were delivered in groups and participants were therefore nested within these groups). Random intercepts for participants were included to model for the correlation of within-person factors at the baseline. The AR1 structure was identified as the model with the best fit with all dependent variables. *Post hoc* analyses for the linear mixed models were conducted with Sidak adjustment. Statistical analysis was conducted in the IBM SPSS 25.0.

RESULTS

Of the 1,079 participants who completed the pre-workshop questionnaire, 299 (27.7%) participants completed the post-workshop questionnaire and were thus included in the analyses. Of the 299, 81 participants also completed the 3-month and 45 completed the 6-month follow-up survey. There were significant differences between those who completed the post-workshop questionnaire and those who did not by gender ($\chi 2(1) = 0.23$, $p < 0.05$), age ($\chi 2(1) = 4.11$, $p < 0.05$), and expected training use ($\chi 2(1) = 6.02$, $p < 0.01$; **Supplementary Table 1**).

A total of 202 participants in the full day and 97 half day workshops were included in the analyses. Demographic information for these participants are presented in **Table 1**. The only significant differences between the two workshop types are that those who participated in the full day more frequently indicated that they would use the training in the future compared

TABLE 1 | Descriptive characteristics of participants included in the study by the workshop type (full day vs. half day training).

		Community full day (N = 202)		Community half day (N = 97)		X^2	p
		N	%	N	%		
Gender	Male	30	14.9	14	14.6	0	0.95
	Female	172	85.1	82	85.4		
Age	Below 35 years	37	18.3	25	26.0	2.36	0.13
	35+ years	165	81.7	71	74.0		
Aboriginal and Torres Strait Islander	Aboriginal	9	4.5	5	5.2	0.07	0.79
	Other Australian	193	95.5	92	94.8		
CALD	CALD	23	11.4	11	11.3	0	0.99
	Non-CALD	179	88.6	86	88.7		
State or Territory	ACT	9	4.5	5	5.2		0.78[+]
	NSW	80	39.8	46	47.4	1.64	0.20
	NT	7	3.5	5	5.2		0.53[+]
	QLD	34	16.9	14	14.4	0.28	0.60
	SA	19	9.5	11	11.3	0.27	0.60
	TAS	3	1.5	1	1.0		1.00[+]
	VIC	19	9.5	15	15.5	2.39	0.12
	WA	30	14.9	0	0		<0.001[+]
Work discipline	Community support/carer	93	51.7	43	50.0	0.17	0.92
	Health sector	20	11.1	11	12.8		
	Other	67	37.2	32	37.2		
Working in suicide prevention	Never	63	31.3	41	42.7	4.80	0.31
	0 to 12 months	40	19.9	15	15.6		
	1-5 years	31	15.4	10	10.4		
	5-10 years	32	15.9	12	12.5		
	10+ years	35	17.4	18	18.8		
Previous suicide training		49	25.3	18	19.1	1.32	0.25
Expected to use training		199	98.5	89	92.7	6.77	0.01

CALD, Culturally and Linguistically Diverse.
[+]Fisher's exact (2-sided) was used for analyses where <80% of the cells have expected values of 5 or less.

to those in the half-day workshop ($\chi 2(1) = 6.77$, $p < 0.01$). Changes in the main outcome measures over the study period are presented in **Figure 1**.

Reluctance to Intervene: Mixed-effects regression analysis (**Table 2**) showed that time was a significant predictor of the change in mean score of reluctance to intervene (i.e., less reluctance) ($F_{(3,55.3)} = 9.74$, $p < 0.001$), but not workshop type, nor the interaction of time and workshop type. *Post-hoc* analyses (ST 2) indicated that there was a significant increase in scores from pre-to post-intervention (Mdif = 1.46, 95%CI: 0.71, 2.22; $p < 0.001$), but not from pre to 3-month follow-up (Mdif = 1.49, 95%CI: 0.33, 3.87; $p = 0.15$). There was some decline in scores observed after 3-month follow-up.

Perceived Capability Scale: For perceived capability, time was a significant predictor of the change in mean score ($F_{(3,316.7)} = 258.38$, $p < 0.001$), but not workshop type, nor the interaction. *Post-hoc* analyses (ST 2) indicated that there was a significant increase from pre-to post workshop (Mdif = 20.28, 95%CI: 18.34, 22.22; $p < 0.001$) from pre to 3-month follow-up (Mdif = 17.97, 95%CI: 12.95, 23.75; $p < 0.001$), and from pre to

6-month follow-up (Mdif = 12.76, 95%CI: 5.26, 20.27; $p < 0.001$). Although decline from post to 3-month follow up was not significant, it was significant from 3-month to the 6-month follow-up (Mdif = -7.52, 95%CI: $-5.00, -0.03$; $p < 0.05$. Younger age ($F_{(2,127.9)} = 4.47$, $p < 0.05$), longer experience in suicide prevention ($F_{(4,128.8)} = 5.36$ $p < 0.001$), and previous suicide training ($F_{(1,129.9)} = 12.67$, $p < 0.001$, ST 3) also predicted higher perceived capability scores across all time periods.

Declarative Knowledge Scale: Time was also a significant predictor of the change in mean score of declarative knowledge ($F_{(3,92.6)} = 124.81$, $p < 0.001$), but not workshop type. Some time and workshop interaction was observed ($F_{(3,92.4)} = 2.69$, $p = 0.051$). Nevertheless, *post hoc* analyses revealed that there were no differences between workshop types at any time point. Overall, for both workshops there was a significant increase from pre-to post workshop (Mdif = 0.22, 95%CI: 0.19,0.25; $p < 0.001$, ST 2) from pre to 3-month follow-up (Mdif = 0.20, 95%CI: 0.13,0.27; $p < 0.001$), and from pre to 6-month follow-up (Mdif = 0.18, 95%CI: 0.10,0.26; $p < 0.001$). These gains were maintained with no significant differences from post- to 3-month follow-up,

FIGURE 1 | Mean scores with 95% CIs of outcome measures at pre, post, 3-months and 6-month follow-up after community half day and full day Wesley LifeForce training.
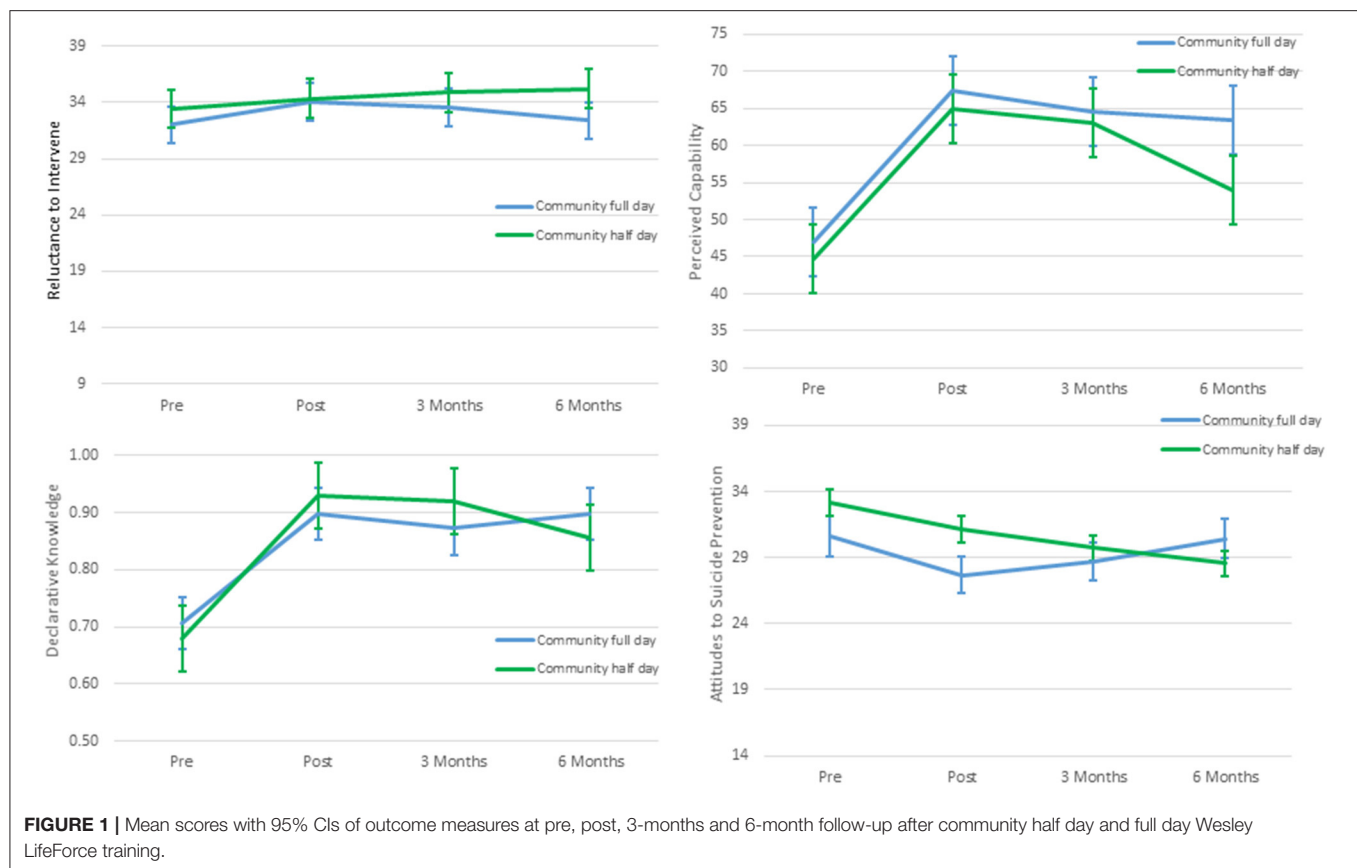
TABLE 2 | Fixed effect estimates for outcome measures by time, workshop type and workshop type × time interaction[1].

	Time			Workshop type			Workshop type × Time		
	F	df[2]	p	F	df[2]	P	F	df[2]	p
Reluctance to intervene	9.74	55.3	<0.001	1.54	149.7	0.22	1.57	55.7	0.21
Perceived capability	258.38	316.7	<0.001	1.71	166.6	0.19	0.58	316.1	0.63
Declarative knowledge	124.81	92.6	<0.001	0.00	151.6	0.95	2.69	92.4	0.05
Attitudes to suicide prevention	16.41	58.3	<0.001	0.46	141.9	0.50	1.70	59.6	0.18

[1]model included also gender, age group, years in suicide prevention, work discipline, training use and prior suicide training (detailed results in ST 3).
[2]denominator degrees of freedom. Numerator degrees of freedom are as follows: Time (3), Workshop type (1), Workshop type × Time (3).

and from 3-month to 6-month follow-up. More experience in suicide prevention ($F_{(4,121.7)} = 4.11$, $p < 0.01$), and those who had previous suicide training ($F_{(1,120.2)} = 5.98$, $p < 0.05$) also predicted higher declarative knowledge scores (ST 3) across all time periods.

Attitudes to Suicide Prevention scale (ASP): Similarly, time was a significant predictor of the change in mean score of the attitudes to suicide prevention scale ($F_{(3,58.3)} = 16.41$, $p < 0.001$), but not workshop type nor the interaction. There were no significant differences at pre-, 3-month, or 6-month follow-up for each type of workshop. However, overall, for both workshops, there was a significant difference from pre-to post workshop (Mdif=-2.46, 95%CI: $-3.42, -1.50$; $p < 0.001$) and pre to 3-month follow-up (Mdif = -2.66, 95%CI: $-5.26, -0.05$;

$p = 0.04$) indicating a decrease in negative attitudes. Despite these drops (meaning lower negative attitudes) from post- to 6-month follow-up, and from 3-month to 6-month follow-up, these were not significant. Younger age ($F_{(1,109.9)} = 4.37$, $p < 0.05$), previous suicide training ($F_{(1,118.5)} = 4.49$, $p < 0.05$) also predicted lower negative attitudes to suicide prevention scores (ST 3).

DISCUSSION

The main aims of the current study were to evaluate the effects of Wesley LifeForce suicide prevention training targeted at the general community by analyzing the endurance of their impacts on a number of measures, and to compare the impacts of full day and half a day programs. The results support the

effectiveness of Wesley LifeForce Suicide Prevention training, for the full and half day training packages for community GKs. All outcome measures including perceptions of capability, declarative knowledge, attitudes toward suicide prevention and reluctance to intervene showed immediate improvements from pre- to post-training. Moreover, these gains were all maintained from post to 3-month, and from 3- and 6-month, with the exception of perceived capability, whereby scores decreased after 3 months follow up.

We did not identify any significant differences in outcomes between participants attending full day or half day workshops. Although there was a significant interaction between workshop types and time for declarative knowledge, *post hoc* analyses indicated there were no significant differences between workshop types at any time. Similarly, Cross et al. (20) compared brief GKT vs. GKT plus behavioral skills training to determine their impacts on skills and use of training and found significant increases for *both* workshops in attitudes and knowledge at post training as well as follow-up (20). However, those who received skills training via role play and behavioral rehearsal showed higher total skills scores (20). It is well established in the GKT literature that knowledge does not necessarily translate to practice (21). A recent systematic review of school-based GKT revealed that only three studies (out of 14) had measured GK behavior/skills changes, which showed generally significant positive effects from pre to post training. However, upon closer examination of these findings, no studies reported maintenance of positive changes and the combined findings implied that the knowledge and skills-based changes may not translate to behavior change (22). However, it was also suggested that this finding may be a result of short follow-up periods during which it is difficult to identify any changes (particularly based on lesser opportunities to apply the skills) (22). Nevertheless, as the application of skills to the real world is the least measured outcome in GKT studies, it is important that such outcomes are included in future investigations.

Reluctance to Intervene

Related to one's motivation to intervene, this study found less reluctance to intervene with a suicidal person post training, with this difference sustained until the 6-month follow-up. This aligns with other studies that have shown reduced reluctance levels post training, maintained at 5 months post training (10), even when using a randomized control group design (11). However, in the few studies that have looked at the translation of intentions or motivations to intervene following training, there seems to be no association with putting this into practice as measured by self-reported behavioral change (11). As discussed above, while we were unable to measure the behavioral change implications, it would seem important to place additional emphasis within both types of LifeForce training workshops on discussing and practicing ways to overcome potential obstacles to utilization of skills in real-life situations. As stated, only the Lifeforce full day workshop includes skills-based activities, so while we did not find differences between the different formats of delivery, it would be worthwhile measuring specific skills based outcomes between them in the future to better understand their impact

of skill utilization. Further, the LifeForce training should pay specific additional emphasis on the role-playing elements of intervention in the context of discussions about the influence of skills-rehearsal on willingness to intervene and reducing discomfort that can often accompany intervention behaviors (23–25). Additionally, some type of professional support or booster training is recommended at least within the 3-months post training to sustain a willingness to respond to and intervene with suicidal persons.

Perceived Capabilities and Declarative Knowledge

Assessment of perceived capabilities in suicide prevention included examination of a suite of minimum competencies aligned directly with the LifeForce training packages in the form of a self-report measure. This is an important measure as it has been shown previously that confidence in personal abilities can have positive effects on motivating and encouraging participation in suicide prevention activities (15, 26). We found that perceived capability increased post-training and was sustained up to 3-months but decreased at 6-months. This attrition could be related to the lack of opportunity to utilize knowledge and skills over time, despite being unable to report on the opportunities presented to participants to engage suicidal persons during the study period. Nevertheless, it seems fair to assume that informal GKs have much less frequent contact with persons at risk of suicide compared to formally designated GKs whose work necessitates the ongoing use of GK capabilities as part of their role (6).

Our examination of participants' declarative knowledge (a more objective account of assessing suicide prevention facts, directly aligned with LifeForce training learning objectives) showed significantly enhanced knowledge post-training which was maintained over the follow-up period. This is consistent with other findings where GK training has improved suicide-related knowledge in diverse community populations (5–7, 27).

We also found that prior training in suicide prevention and more experience in suicide prevention predicted higher scores on perceived capability and declarative knowledge. Other studies have reported similar associations between prior training and experience with more enhanced training outcomes. For example, GK studies on health professionals (28), and workers from diverse behavioral and health fields (29) have found prior suicide training to be related to greater knowledge and confidence in GKT outcomes. Increased practice and rehearsal of acquired capabilities is known to maintain skills, which may in turn maintain both actual knowledge and perceptions of capabilities (20). Provision of booster training and other supportive education may enhance capability and reinforce acquired skills in the absence of opportunities for intervention. This may be particularly important for informally denoted GKs who are not regularly in contact with suicidal persons.

Attitudes to Suicide Prevention

Regarding attitudes outcome, we found that negative attitudes to suicide prevention decreased from pre to post-workshop and from pre to 3-month follow-up but not also to 6-month

follow-up. Positive attitudinal change toward suicide prevention is one of the most difficult GKT outcomes to sustain long-term, as demonstrated in a recent review by Yonemoto et al. (30) which identified only one RCT study that found attitude changes sustained to 6 months post training among youth helpers (13). We observed that younger age and those with prior training had more positive attitudes, compared to those with no prior training. This demonstrates that regardless of the impacts of LifeForce training, the individual's pre-training experience arguably plays a role in current attitudes toward suicide and suicide prevention. Consistent with the extant literature on attitudes and GKT (15), our results endorse that training generally can result in more positive attitudes for the better, however, this outcome cannot be solely attributed to the impacts of LifeForce workshop.

LIMITATIONS

Our study has several limitations and results should be interpreted against this background. Firstly, in light of the fact that there were some significant differences between completers and non-completers, it is possible that the study suffers from a self-selection bias which may have impacted results. Further, other methodological limitations may prevent causal links being made between LifeForce Training and the enduring participant gains. We did not use a control group to compare different training program effects so were unable to conclude whether competency gains were the result of LifeForce training *per se*, or whether such impacts might be gained from a multitude of other influences. Moreover, not all training attendees participated in the research, and attrition rates were quite high over all time periods; similar experiences were reported by other studies including heterogeneous community samples (11). We attempted to address this limitation through the use of mixed linear modeling as this method accounts for within- and between-participant variance and accounts for correlations between repeated measures for each participant. Finally, scales measuring reluctance to intervene and attitudes to suicide prevention had low internal consistency, in both the original scale development studies and in the current study. Thus, it is possible that results obtained on these scales are not robust enough to be conclusive.

CONCLUSION

We found evidence for effective impacts of the Wesley LifeForce training over time, for both the short (half day) and longer (full day) formats of delivery. The latter format offers skills-based and skills rehearsal opportunities which we were unable to measure in this evaluation, but which we recommend be emphasized in future evaluation studies of this

program. Specifically, findings revealed that training participants exposed to LifeForce training are likely to experience increased perceived capability, declarative knowledge, positive attitudes and reduced reluctance associated with intervening, at least in the short term. In particular, the program is well targeted for those with no prior training, despite those with prior training also experienced positive and significant gains on nearly all measured constructs. Community members and organizations with different professional background undertaking this training can expect to gain significant learning's and gains in key factors known to impact intervention behaviors.

DATA AVAILABILITY STATEMENT

We have not provided this statement. The raw data can be made available upon a reasonable request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Griffith University Human Research Ethics Committee. The participants provided consent by progressing past the information sheet informing them that continuation into the online survey will represent their consent to participate.

AUTHOR CONTRIBUTIONS

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SUPPLEMENTARY MATERIAL

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Promoting Student Wellness and Self-Care During COVID 19: The Role of Institutional Wellness

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Stress and burnout are serious and growing threats to the mental health of medical trainees. Recent estimates of burnout in medical students and residents are quite high, with more than half displaying signs of stress, anxiety and depression. The COVID-19 pandemic has only heightened the state of poor mental health in these student populations. It is the position of LSU Health Shreveport Office of Institutional Wellness that a critical need exists for academic institutions to evaluate challenges to self-care and wellbeing in medical trainees. Such evaluations may pave the way for the development of effective institutional wellness initiatives and strategies, with the goal of reducing barriers to self-care to promote better mental and physical health, and facilitate improved quality of life in medical students and residents.

Keywords: COVID-19, medical students and residents, self-care, burnout, poor mental health

INTRODUCTION

The COVID-19 pandemic created widespread stress and anxiety in the US population. Social distancing, increasing joblessness and limited access to mental health services, created an increased mental health burden during and beyond the pandemic (1–7). Student mental health has been a growing issue in academia. Even prior to the pandemic, national data sources displayed increased rates of burnout, depression, eating disorders, alcohol abuse and self harm in student populations (8). According to the 2019 Annual Report of the Center for Collegiate Mental Health, anxiety continued to be a widespread problem with numbers as high as 62.7% (9). The pandemic has only worsened students' mental health, with studies reporting increases in alcohol dependence, burnout, depression, suicidality, and fatigue (10–12). Studies have also displayed medical trainees may also be less likely to seek treatment due to the stigma of mental illness, and the perception of not being able to handle the rigors of medical training (10, 13).

Students of color (SOC) have been disproportionately impacted during the pandemic, displaying poorer outcomes with COVID-19 as well as increased rates of anxiety and depression (12, 14). Poorer mental health in SOC is often due to underlying social inequities, such as food and housing insecurity, racial and ethnic discrimination, and decreased access to technology required for online learning (12, 14).

One tactic to promote wellness and reduce stress during the rigors of medical training is to engage in self-care activities (15, 16). These activities should address the varied dimensions of wellness including physical activity, socialization, proper nutrition and stress management (17). However, the demanding pace of medical training often makes it a challenge for students to prioritize the time required for self-care activities (18).

Ayala et al., in a 2017 study on self-care, found "a robust inverse relationship between perceived stress and medical students' quality of life" (17). The authors concluded that their findings suggested self-care may be an effective strategy for reducing the effects of stress and burnout in medical students.

In addition, early application of self-care during medical training may promote sustainable healthy behaviors post-graduation (19). Sustainability of self-care is important post-graduation, as the literature reports that healthcare workers, including physicians, have experienced impaired mental health during the COVID-19 pandemic (20, 21). Protection of the mental health of physicians and other healthcare workers has been labeled as important by the World Health Organization in 2020 (22).

Due to the increased prevalence of mental health impairments in medical students and residents, investigating the relationships between poor mental health and the challenges faced in initiating self-care may assist academic institutions to better understand these issues and offer more effective wellness initiatives that address the barriers currently faced by trainees.

POSITION

It is the position of LSU Health Shreveport, Office of Institutional Wellness that medical student and resident burnout is a significant issue, and lack of self-care is often overlooked as a contributing factor. A pressing need exists to evaluate the role of self-care to increase overall wellbeing and to combat burnout and stress during medical training. LSU Health Shreveport is committed to reducing student burnout by assessing and addressing the issues causing and fueling poor mental student health and by providing an academic environment that values wellness and self-care.

DISCUSSION

Medical trainees commonly experience stress and burnout, and poor mental health greatly contributes to decreases in their quality of life (9, 11, 13, 23). Researchers and wellness advocates maintain not practicing self-care during medical training is detrimental to mental and physical health and further contributes to increased risk of burnout and stress (15–17).

Promotion and facilitation of self-care during medical training is vital in order to promote long-term lifestyle modification that is sustainable post-graduation. This is important, as the literature displays that the mental health of medical professionals, not just medical students, has been challenged during the pandemic (20, 21, 23, 24). Further, poor mental health has been shown to be exacerbated when medical professionals feel unsupported by administration regarding wellbeing initiatives (20).

It is vital that academic institutions provide an organizational culture of wellbeing by assessing challenges to self-care and by implementing institutional strategies and measures that encourage sound mental and physical health. Such initiatives can include online wellness platforms, support groups, increased access to mental health services, classes on yoga, mindfulness, sleep health, time management, nutrition and fitness, as well as longitudinal wellness index surveys (25–27).

To facilitate self-care, virtual/in person classes on the importance of stress management, nutrition, sleep health and meditation can be incorporated into the matriculation process. Faculty and community wellness advocates can facilitate these classes during lunch hours or protected time allotted for self-care. Offering these types of classes during medical training is vital, as trainees whom increase their knowledge and practice self-care can more effectively weather school-related stress and build better resilience (28).

Longitudinal wellness index surveys can be used effectively to monitor stress and burnout (23, 25). These surveys provide complete anonymity to remove the fear of self-assessing, and trainees can compare their wellbeing measures to peers' and national averages. They can also gain access to local and national resources on stress/resiliency, work-life integration, and resources to combat or prevent alcohol/substance abuse to help improve their wellbeing. These surveys allow for continuous measurement through periodic reassessments in order for trainees to track their progress over time. They can also allow academic institutions to assess periods of high stress in trainees, to allow for better planning and scheduling of self-care activities.

In addition, addressing barriers to self-care is vital to ensure sound participation (18, 29). Due to the demanding pace of medical education and training, students and residents may perceive wellness activities as an encroachment on their time, which in turn may inadvertently increase stress levels and decrease their participation (18). Perceived loss of time from participating in wellness activities can be lessened through protected time for self-care activities. It can also be mitigated by incidental physical activity challenges. Incidental activity is defined as activity performed in small increments over the course of day. It tends to be less structured than a planned exercise session, and can occur in many forms (i.e. skipping the elevator and taking the stairs, walking during lunch or spending more time standing than sitting during the day). These activity challenges are easy to employ on a daily basis and students/residents may feel less threatened by them as they can be performed without further constraints on their time. Another way to address this barrier is to offer online wellness platforms that provide exercise and wellness classes on demand, so medical trainees can take classes when it best fits their schedules. Finally, sponsorships to local community gyms where trainees can meet to partake in team sporting tournaments and events can assist with increasing physical activity with the added benefit of socialization with peers.

Due to the COVID-19 pandemic, there has been an increased need for student mental health interventions, however due to time restrictive schedules, students and residents may not seek out treatment for poor mental health. To combat this challenge, behavioral health/counseling centers can add flexible hours (after hours or weekends), and provide a 24/7 crises management hotline to assist with emergent mental health issues.

Further, it is important to remember that the COVID-19 pandemic has not affected trainees equally, and has exacerbated the distinct mental health issues faced by SOC, lesbian, gay,

bisexual, transgender, queer (LGBTQ) students, and students that are economically disadvantaged (12, 14). Academic institutional leadership needs to be aware of cultural issues that can impact both physical and mental wellbeing in underrepresented minority students and residents. Culturally based stigmas surrounding mental health care, an inherent distrust of the health care system or a lack of providers from diverse racial/ethnic backgrounds can be barriers to seeking out treatment. Providing counselors from diverse genders and backgrounds can assist with reducing these barriers and facilitate culturally competent care to all students. Further, staff should receive training on implicit bias, cultural awareness, sensitivity and competence. Cultural competence training is utilized to "increase therapists' awareness of their own assumptions, values, and biases and knowledge of research, assessment, and practice" (30). Such training can facilitate more equitable care and improve outcomes, particularly to students from culturally and linguistically diverse backgrounds (30, 31).

CONCLUSIONS

Physical and emotional wellbeing are key to academic success in medical education. However, medical students and residents face poor mental health due to the rigors of their training and decreased ability to practice self-care. Research studies report medical trainees and healthcare professionals are at increased risk for poor nutrition, reduced sleep health, depression, and suicide. This is especially true in underrepresented students and residents. These conditions have become even more prevalent

after COVID-19. Self-care has been shown to attenuate poor mental health and stress, however due to time constraints during medical training, few seek out or practice wellness activities. Increasing opportunities for medical trainees to participate in self-care activities during their training, can assist them in developing strong values for self-care, and become better wellness advocates to future patients. A fundamental shift recognizing the essential role of self-care is needed in order to address the epidemic of stress and burnout among medical trainees. Academic institutions must also understand and address the barriers students and residents face in regards to practicing self-care and wellbeing, and emphasize initiatives that address burnout-related issues and provide beneficial, culturally competent resources. Helping students and residents recognize the importance self-care and wellness during their medical training assists them in developing resilience, which will help them deal with stress more effectively during their matriculation and post-graduation, and improve their quality of life.

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 author confirms being the sole contributor of this work and has approved it for publication.

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Catalytic Reaction Model of Suicide

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Suicide is a devastating outcome of unresolved issues that affect mental health, general wellbeing and socioeconomic stress. The biology of suicidal behavior is still poorly understood, although progress has been made. Suicidal behavior runs in families and genetic studies have provided initial glimpses into potential genes that contribute to suicide risk. Here, we attempt to unify the biology and behavioral dimensions into a model that can guide research in this area. The proposed model envisions suicidal behavior as a catalytic reaction that may result in suicide depending on the conditions, analogously to enzyme catalysis of chemical reactions. A wide array of substrates or reactants, such as hopelessness, depression, debilitating illnesses and diminished motivation can mobilize suicidal thoughts and behaviors (STBs), which can then catalyze the final step/act of suicide. Here, we focus on three biological substrates in particular: threat assessment, motivation to engage in life and impulsivity. Genetic risk factors can affect each of these processes and tilt the balance toward suicidal behavior when existential crises (real or perceived) emerge such as loss of a loved one, sudden changes in social status or serious health issues. Although suicide is a uniquely human behavior, many of the fundamental biological processes are evolutionarily conserved. Insights from animal models may help to shape our understanding of suicidal behavior in man. By examining counterparts of the major biological processes in other organisms, new ideas about the role of genetic risk factors may emerge along with possible therapeutic interventions or preventive measures.

Keywords: suicide, suicidal ideation (SI), threat assessment, diminished motivation, impulsivity

The anguish of someone preparing to take their own life is clearly unbearable and staggers comprehension. Moreover, the loss and grief of loved ones, family members and colleagues of people who die by suicide are incalculable and unrelenting. Unfortunately, suicides and suicide attempts are not rare, isolated events. Worldwide more than 700,000 people die by suicide each year and about 20 times this number will attempt suicide (1). Depending on the age group, suicide is a leading cause of death (1). Beyond the act of suicide or attempted self-harm, suicidal thoughts and behaviors (STBs) manifest in about 10% of the population at some time in their life (2) with higher prevalence in those with psychiatric disorders such as major depression, bipolar disorder, schizophrenia and anxiety disorders (3). In fact, the majority (∼90%) of individuals who die by suicide suffered from a psychiatric condition prior to taking their life (4). However, mental illness is not a required state of mind and it is counterproductive to believe this is the case. Any theory must consider suicide broadly and clinicians must screen for suicidal ideations in addition to psychiatric disorders.

Suicide is potentially a preventable outcome if we can identify individuals with plans and intentions prior to their final actions. Although progress has been made in identifying risk factors for suicide such as presence of psychiatric disorders, previous suicide or self-harm episodes and advanced suicidal ideation, we still lack precise prediction methods. Furthermore, the success of available interventions is limited.

The fact that suicide tends to cluster in families (5, 6) provides a clue that genetic predisposition may be an important factor. Indeed, the heritability of suicidal behavior is on the order of 40–50% (7, 8), commensurate with the heritability of psychiatric disorders including major depression and bipolar disorder (9–11). Genome-wide association studies (GWAS) and other investigations have identified gene candidates that increase the risk for STBs and suicide (12–16); however, none of the risk genes have yet reached the stage of predictive value. This failure owes, in part, to the lack of context or biological mechanisms that link the risk genes to behaviors associated with suicide.

The neurobiological basis of suicidal behavior is multifaceted and includes significant contributions from the serotonergic system, the hypothalamic-pituitary-adrenal (HPA) axis [(17); discussed below], neuroimmune function and the endocrine system. Excellent reviews on these topics are available (17–22). Cytokines, especially IL-6 and TGF-b, appear to play a role in the emergence of STBs (14, 20). In addition to the HPA axis, neuroendocrine factors such as neuropeptide Y [NPY; (23–25)] and insulin (26, 27) have been implicated in the emergence of suicidal behavior, which will be discussed further in a later section. Detailed discussion of the neurobiology of suicide is beyond the scope of this review.

The purpose of this article is to introduce a novel model of suicide that integrates biology, genetics and brain circuitry to explain the various factors driving STBs. We will begin by describing current major theories of suicide and discussing their shortcomings before developing the catalytic reaction model of suicide.

THEORIES OF SUICIDE

To understand the factors contributing to suicidal behavior and suicide, different theories, dealing mainly with psychological mediators, have been postulated. Most recent models fall into the broad classification of ideation-to-action theories (28) and will be briefly outlined here as a basis for comparison with the new catalytic reaction model, which redefines this ongoing process.

Mann and colleagues (29) proposed a stress-diathesis model of suicide based on differences observed in state and trait factors between suicide attempters and matched psychiatric patients without suicide attempts. Although not explicitly an ideation-to-action theory, the model does treat the suicidal act as a separate event. Risk factors that distinguished persons attempting suicide in this study included suicidal ideation, hopelessness, impulsivity and fewer reasons for living along with a family history of suicidal acts, head injury, smoking and childhood abuse. The suicidal act may be precipitated by a combination of baseline stress or a psychiatric disorder coupled with feelings of hopelessness or

new perceived threats, which trigger suicidal ideation. The switch from risk state to action may be hastened by impulsive behavior that facilitates acting on suicidal thoughts.

The Interpersonal Theory of suicide was formulated by Joiner et al. (30) and was the first to specify two distinct stages to suicide: the emergence of suicidal desire and the capability to engage in suicidal behavior. Two main factors drive suicidal desire, namely thwarted belongingness and perceived burdensomeness. In addition, there may be a sense of hopelessness about these two emotional states. The capability for suicide stems from adaptation to painful events such as family conflict, abuse, mental disorders, physical illness and previous suicide attempts that reduces the fear of death and disinhibits decisions for lethal action. Finally, the desire for suicide is a dynamic process, whereas the capability for suicide is thought to reflect stable and unchanging factors.

O'Connor developed the Integrated Motivational-Volitional Model of suicide in a series of papers (31, 32). Similar to Joiner's theory, there are two behavioral stages – the motivation to commit suicide and the volition or commitment to carry out lethal action – that are distinct and governed by different factors. The motivational phase is driven by feelings of defeat/humiliation and entrapment leading to suicidal ideation and initial intent. Separately, the ultimate decision to end one's life is moderated by such factors as impulsivity, fearlessness about death and cognitive input (planning) along with access to lethal means. In addition, O'Connor proposed a pre-motivational phase that included extant risk factors (e.g., genetic or cognitive vulnerability), environmental conditions and stressful life events, which together can determine the propensity for STBs.

To illustrate the range of conceptualization of possible causes of suicide, we briefly mention three additional theories that are variations on the ideation-to-action scheme, namely Three-Step Theory (33) Fluid Vulnerability Theory (34) and the Cusp Catastrophe model (35, 36). Klonsky et al. (33) describe suicide as a three-step process: (1) suicidal ideation is generated by a combination of psychological pain and hopelessness, (2) this ideation strengthens when the pain overwhelms feelings of belonging or connection and (3) suicidal ideation transitions to planning and action when the person acquires the capacity for suicide. The psychological pain includes feelings that "one is essentially being punished for engaging with life, which in turn brings a desire to avoid life" (28). When combined with hopelessness about the situation(s), suicidal ideation emerges. The acquired capacity to commit suicide relies on similar factors discussed above including access to lethal means and reduced fear of death. In the FVT model, Rudd (34) focuses on the fact that STBs are a dynamic process that are subject to change over time. Baseline risk factors are relatively stable and differ between people, whereas acute suicidal behavior fluctuates driven by life events and stressors and is time limited. Functional activity across integrated systems – cognitive, affective, physiological and behavioral – determines entry into suicidal mode, the separate action phase of this model. An offshoot of the FVT model, the Cusp Catastrophe Model of suicide also emphasizes the dynamic nature of suicidal behavior and envisions sudden, and typically unpredictable, transitions from low-risk suicide states

to high-risk states driven by nonlinear effects of rapid changes (35, 36).

LIMITATIONS OF CURRENT THEORIES OF SUICIDE

The main theories summarized here, along with others [e.g., by Wenzel and Beck (37) and Roberts and Lamont (38)] not discussed (see **Table 1**), have significant heuristic value and have greatly impacted the field of suicidology. In general, they share common themes and underlying processes: hopelessness/defeat, a sense of burdensomeness, the motivational drive of suicidal ideation and a distinct acquired suicide capability/mode. Herein, lie some of the shortcomings of current theories of suicide. The major limitation is the conceptualization of the ideation/motivation stage and the volition/enaction stage as distinct and separable processes. According to the various models, ideation leads to action in a linear relationship (28); however, these processes are supposedly governed by different sets of factors. Based on the nonlinearity of most complex biological systems, this concept seems unlikely from first principles. Along similar lines, suicidal ideation, suicide attempts and suicide completions are typically considered as distinct entities instead of lying on a spectrum or continuum. In ideation-to-action theories, the intent of someone who considers suicide is often treated as a distinct, but related, state of mind from the intentions of someone who was successful. Moreover, states of mind clearly fluctuate and decisions are constantly questioned and even changed as new developments impinge

on the status quo. The FVT model (34) addresses some of these issues, but has limited biological underpinnings. On the whole, theories of suicide inadequately incorporate biological and genetic mechanisms to explain STBs [with some exceptions, e.g., see refs. (43–45)]. For the most part, biology and genetics are considered vague and static distal factors that somehow determine the set point for vulnerability to suicide and are seldom viewed as dynamic processes differentially affecting mental states depending on everchanging conditions. For example, genetic predisposition to conserve effort and ambition when the chance for reward is low (a resiliency factor) may protect against the financial stress of recent job loss, whereas it may exacerbate a later response to social isolation because efforts to engage with others are reduced.

The fact that there appear to be different types of suicide presents a serious challenge to any comprehensive theory of causation. A suicide committed in the depths of relentless depression appears different from that committed by someone diagnosed with a severe or terminal illness and who wants to minimize the burden on their family, and different still from the actions of a "suicide bomber." In all cases, the outcome is the same, but any similarities in the paths toward that end remain obscure.

GENETIC AND BIOLOGICAL CONSIDERATIONS OF RISK FOR SUICIDE

In the theories discussed so far, genetic factors are considered to be distal or fixed pre-motivational contributors to risk for suicide. Suicidal behavior has a strong familial component (5, 6) and genetic studies confirm strong heritability (7, 8). Consequently, candidate gene analysis and unbiased genome-wide association studies (GWAS) have been conducted to identify risk genes and characterize the genetic basis of suicide. Interesting risk-gene candidates have emerged from this work (12–16): CACNA1C/D (calcium channel subunits), GNAS (G protein subunit alpha S), PDPK1 (3-phosphoinositide-dependent kinase-1), STK33 (serine/threonine kinase-33), HIPK2 (homeodomain interacting protein kinase-2), DCC (netrin 1 receptor) and NTRK2 (neurotrophic receptor tyrosine kinase-2). However, their mechanistic roles in shaping STBs have not yet been established. Moreover, genetic risk has not been integrated very well in most models of suicidal behavior.

Variation in a single risk gene will not cause all of the motivational and suicidal behaviors associated with suicide in man. Perhaps, hundreds of risk genes contribute – each to a small extent – as is the case in most psychiatric disorders (46–49). Therefore, translating genetic variation into the proximal causes of suicide attempts may require investigation of endophenotypes, which are observable traits, behaviors or quantifiable measures mediating a gene's effects on complex disorders/behaviors such as suicide. Ideally, it should be possible to study counterparts of the endophenotypes in animal models (50). Several endophenotypes appear to qualify in this regard: impulsive and aggressive traits, HPA axis response to stress, hopelessness, and serotonergic system dysfunction (18, 19, 50, 51). Here, we propose that

TABLE 1 | Summary of notable theories of suicide*.

Authors	Date	Brief description	References
Durkheim E	(1897) 1951	Sociological basis of suicide	(39)
Shneidman ES	1985	Psychological pain - psychache	(40)
Rubinstein DH	1986	Stress-diathesis model	(41)
Baumeister RF	1990	Escape theory of suicide	(42)
Mann JJ, et al.	1999	Clinical model of suicide	(29)
Rudd MD	2006	Fluid vulnerability theory (FVT)	(34)
Wenzel A & Beck AT	2008	Cognitive model of stress/suicide	(37)
Van Orden KA, et al.	2010	Interpersonal theory of suicide	(30)
Roberts M & Lamont E	2014	Existentialist reconceptualization	(38)
Klonsky ED & May AM	2015	Three-step theory of suicide	(33)
O'Connor RC & Kirtley OJ	2018	Integrated motivational-volitional model	(31)
Bryan CJ, et al.	2021	Cusp Catastrophe model	(35, 36)

*The table provides a selective historical overview of influential theories of suicide; it is not intended to be comprehensive. The authors and dates listed refer to the corresponding references cited and not to the date associated with the origins of a particular model.

diminished motivation states, threat assessment and stay vs. go decisions (resolution of opposing behaviors *via* neural circuitry) should be added to the list of relevant phenotypes. These phenotypes are congruent with the Research Domain Criteria (RDoC) formulation of suicidal behaviors by Glenn et al. (45, 52). The five domains consist of Negative Valence Systems, Positive Valence Systems, Cognitive Systems, Systems for Social Processes and Arousal and Regulatory Systems. Negative Valence Systems include constructs – loss and sustained vs. potential threat (45) – that match threat assessment/existential crisis factors. Positive Valence Systems deal with reward and approach motivation, which corresponds to diminished motivation states, whereas Cognitive Systems reflect constructs such as cognitive control (45), which is involved in selection between opposing behaviors.

Genetic variation will affect gene and protein expression/function, which will in turn affect biological outcomes such as cortisol levels, serotonergic neurotransmission, dopaminergic counter-regulation and relevant neural circuitry. These biological activities mediate responses to stress, levels of impulsivity, motivation to engage in life functions and social behavior. Thus, genes determine the biological substrates of STBs that ebb and flow in response to changes in the environment. Furthermore, environmental factors will interact with genetically-influenced endophenotypes. For instance, a genetic tendency for low motivation to engage with others may lead to acute social isolation when exacerbated by loss of a job with social interactions or a long-distance move away from family. The dynamic nature of suicide risk factors means that biological vulnerability for suicide is person and time specific.

CATALYTIC REACTION MODEL (CRM) OF SUICIDE

The development of a new model of suicidal behavior was motivated by several goals. First, the catalytic reaction model (CRM) reconciles suicidal ideation with subsequent courses of action, and re-emphasizes the dynamic nature of STBs as a spectrum. Second, the CRM incorporates biology and genetics into the theory and to develop ideas that would be testable in animal models. Third, the CRM explains different types of suicide along with the role of environmental factors as contributing conditions for suicide.

The CRM is based on the conceptualization of suicidal behavior as a type of catalytic reaction (see **Figure 1**). In a catalyzed reaction, various reactants undergo chemical reactions available to those molecular species. This occurs at much higher rates in the presence of a catalyst. The catalyst typically lowers energy barriers that limit the reaction, thereby accelerating formation of the product, depending on the levels of the reactants and ambient conditions such as pH and temperature. The reaction may be reversible, but the catalyst generally drives it toward completion. Because the catalyst participates in the reaction, it is likewise influenced by the reactants.

Using this analogy, we suggest that multiple "reactants" can combine in a reaction/response that gives rise to suicidal thoughts, which can then serve as a catalyst for suicidal behavior including planning, attempts and suicide (**Figure 1**). The model encompasses three sets of interacting factors in the suicide reaction: (1) reactants (e.g., hopelessness), (2) external conditions, including environmental impacts such as job loss and personal factors, e.g., adverse childhood experiences (ACEs), and 3) catalysts – suicidal ideation and genetic vulnerability – that lower barriers to action and determine traits/reactants (e.g., burdensomeness or impulsivity) that drive actions, respectively. The reactants in this model are states of mind or behavioral strategies. Suicidal thoughts would represent a kind of catalyst-reactant intermediate whose formation is related to the "concentration" (intensity or severity) of the reactants. In the model, a second potential catalyst for suicide is the individual complement of genetic risk variants that influence the reaction differentially depending on which factors are driving STBs at a given moment. Genetic variation is a catalyst because it can lower the energy barrier (increase vulnerability) to expressing counterproductive behaviors such as hopelessness, feelings of entrapment, etc. or suppress positive coping strategies, thereby activating or accelerating the production of suicidal behaviors. Effects of genetic variation will be mediated through biological substrates of the corresponding behaviors and will include neurotransmitter signaling, neuroendocrine/cytokine function, brain circuitry and more. As reactants shift over time – from loss and anxiety to diminished motivation and hopelessness – genetic variation in different sets of genes will impact the new factors driving STBs. Similarly, environmental factors can potentially modify genetic contributions to the reactants, e.g., *via* epigenetic regulation of genes involved in stress responses and HPA axis hormonal feedback. Environmental factors determine which genes influence the state of mind (reactants) at a given time, whereas genetic factors determine how the person responds to a changing environment. Therefore, genetics is not a fixed contribution to suicide risk. In a fluctuating combination, reactants, catalysts and conditions may generate products in the form of suicide planning (reversible reaction), attempts (quasi-reversible) and completed suicides (irreversible outcome). Whether products emerge will depend on the concentration of reactants and catalysts together with the prevailing conditions at the time, e.g., recent job loss, impending divorce or diagnosis with a terminal medical condition.

The behavioral reaction potentially leading to suicide is dynamic, ongoing (unless interrupted) and subject to fluctuation. If suicidal thoughts are high and certain baseline conditions exist, addition of reactant (e.g., perceived existential threat) or a change in conditions (e.g., social status) can promote completion of the reaction in the form of suicide attempts, regardless of whether or not they are fatal. Conversely, a reduction in reactants (feelings of hopelessness) or a favorable change in conditions (finding a new job) will shift the reaction away from completion (suicide planning and attempts). (Note: in this context, completion refers to halting the progression of planning to prevent a suicide attempt). We envision the entire catalytic reaction as a nonlinear, largely reversible system spanning a continuum from diminished motivation to engage in life to suicidal thoughts and planning, to preparation, attempt and execution. In the model, suicidal thoughts reinforce and magnify
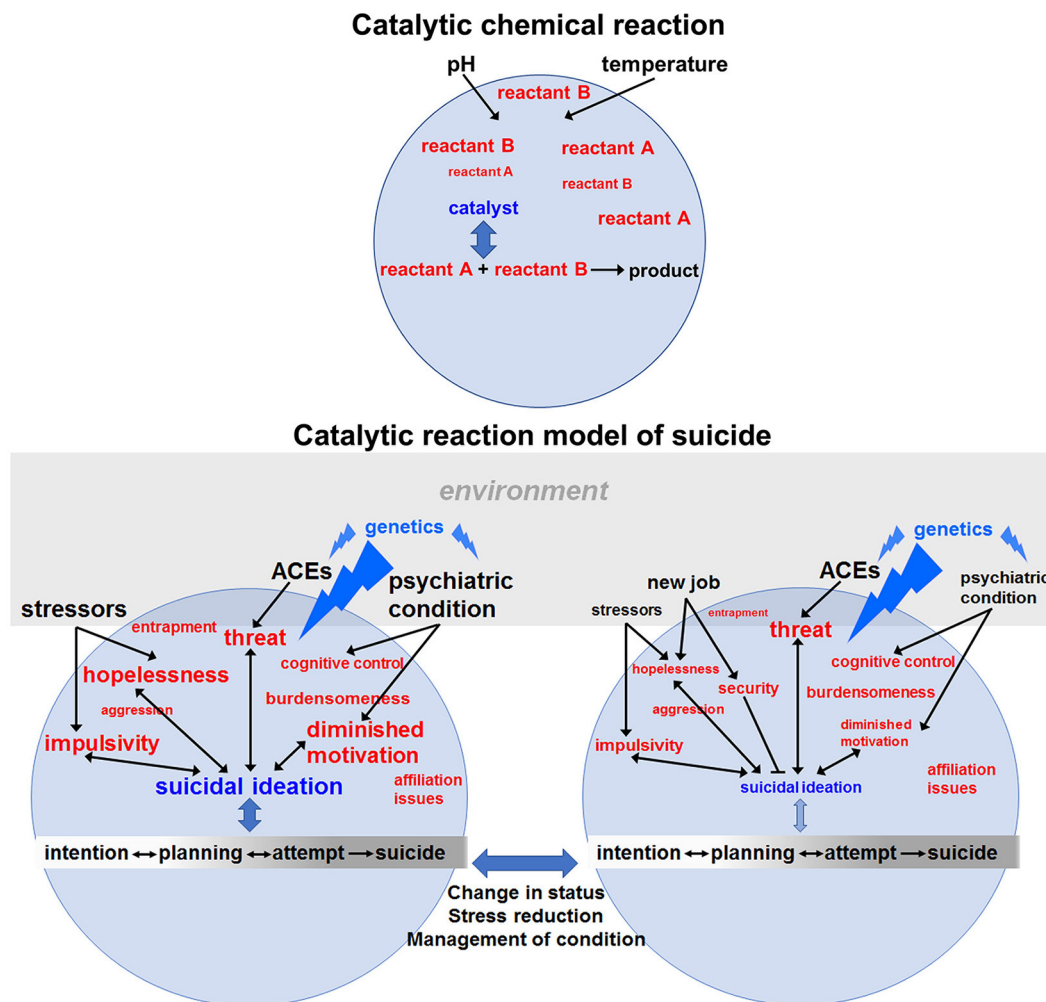
FIGURE 1 | Catalytic reaction model of suicide. In a chemical reaction (upper panel), reactants may combine slowly in the absence of a catalyst, which interacts with both reactants, lowers the energy barrier to the chemical reaction and catalyzes formation of product. Conditions and concentrations of reactants along with the activity of the catalyst determine the rate of the reaction. By analogy, in the lower left panel, various reactants (in red font) combine to determine the catalytic activity of suicidal ideation, which then lowers the "energy" barrier for suicidal behaviors (intention, planning, attempts and completion). The lack of arrows between a pictured reactant and suicidal ideation indicates that at this particular time those factors are manageable and do not contribute to the ongoing suicide reaction. The rate of the suicidal reaction is also determined by environmental conditions (black font) such as stressors or the presence of a psychiatric condition and how well it is being managed. The font size of the reactants and conditions reflects their "concentrations" or "energy" – determined by the intensity, frequency and duration of their effects. Genetic variation (blue font) affects the reaction at several levels by: (1) specifying vulnerability to psychiatric disorders, (2) determining resiliency or acuity in the face of adverse childhood experiences (ACEs) and (3) affecting the emergence and intensity of hopelessness, impulsivity, diminished motivation, etc. in response to changes in the environment. Genetic variants will also affect how a person responds to stressors. As discussed in the next section, genes (e.g., those involved in insulin signaling) affect motivation states, threat assessment (e.g., neuropeptide Y) and impulsivity. In this way, a genetic risk variant can act as a catalyst by lowering the "energy" barrier for expressing various reactants that give rise to STBs. The environment plays a role by affecting motivation (e.g., through reward availability), determining the level of external threat and shaping the context in which opposing behavioral decisions are made. The suicide reaction is dynamic and changes over time, including which risk genes are most important due to differential contributions by different reactants depending on changing circumstances. For example, in the panel at the lower right, the same person represented to the left has now received more effective treatment for their depression and has recently found a new job after a period of unemployment. These changing conditions might lessen feelings of hopelessness, increase a sense of security (a protective factor) and improve motivation to engage in life. Consequently, suicidal ideation is greatly reduced and may be eliminated with continuing progress. Nevertheless, certain levels of impulsivity may remain, and heightened threats may persist due to factors less amenable to change, e.g., ACEs. With lowered concentrations of reactants and a decrease in the catalytic activity of suicidal ideations, residual levels of threat or impulsivity may be tolerable. Suicidal behavior is depicted on a spectrum with arrows showing that some of the processes are reversible. Furthermore, the bidirectional arrows between reactants and suicidal ideation indicate that learned aspects of ideation can feedback to potentially increase feelings of hopelessness, further diminish motivation for enjoyable life activities, etc. The constellation of reactants that drive the reaction will differ between individuals and in relation to their dominance. For instance, a person with a severe debilitating medical condition who contemplates suicide may be primarily driven by feeling like a burden to their family, whereas the ideation of a suicide bomber may be dominated by cognitive control (making disadvantageous choices for political aims) or religious motivations (not depicted). Although two mental states of the individual are represented here, in reality, conditions, reactants and ideation are constantly fluctuating until a crisis is resolved. In our view, prevention should mainly focus on removing threats, promoting engagement in life and mindfulness training to recognize and stop impulsive override of logic. Finally, it will be important to address potential precipitating conditions such as a psychiatric disorder or stressful life events with medications, patient education, coping strategies and therapy as appropriate.

detrimental effects of the reactants to lower the barrier or threshold for action. Consequently, ideation and action are not separate, discrete stages, but are connected *via* dynamic interplay until there is resolution – one way or the other.

What are some of the reactants involved in STBs? Unlike standard chemical reactions (Note: our model is an analogy and not a precise mimic), many reactants may potentially participate in the overall response. Hopelessness, defeat, entrapment, perceived existential threats, reduced fear of death and many other reactants may contribute to the development of STBs (29–31, 33). In the model, we focus on several traits/phenotypes in particular to connect with the biology and genetics in the next section; the correspondence of these phenotypes to **RDoCs** (45) has been highlighted in this section. We underscore the importance of diminished motivation to engage in life (**a motivation/reward construct**), exaggerated threat assessment and impulsivity as three significant reactants in the response. A diminished motivation to engage in life would constitute a necessary first step toward suicidal behavior. It roughly equates with anhedonia (a key feature of major depressive disorder) and hopelessness, an established accompaniment for suicidal ideation (29, 53, 54). Exaggerated threat assessment (**sustained or potential threat constructs**) refers to viewing circumstances such as loss of a job, lack of popularity at school or divorce as palpable threats to one's existence. It is the foundation for existential crises and is a contributor to anxiety disorders, which are often comorbid with STBs (38, 55, 56). Finally, impulsivity reflects acting without thinking through the consequences or emotional responses overriding our logical responses (**cognitive control construct**). It has been identified in numerous studies as an important component of suicidal behavior (29, 57, 58).

CATALYSIS OF STBS BY GENETIC AND DOWNSTREAM BIOLOGICAL FACTORS

If genetic risk is a catalyst that modifies the nature and effective "concentration" of reactants such as diminished motivation or threat assessment, it should be possible to connect the two. Here, we summarize connections revealed in studies of the nematode, *C. elegans*, that suggest certain aspects of suicidal behavior may be fundamental to life, evolutionarily conserved and controlled by genetics. Previously, we (59) identified a state of diminished motivation in *C. elegans* regulated by signaling pathways (e.g., Akt) associated with psychosis (60) and major depressive disorder (61). Animals with defects in the insulin receptor gene and downstream signaling components fail to forage in response to food deprivation and will remain in place until they die (59). They are capable of movement during this time, but remain largely immobile, which is reminiscent of the response of mice and rats in the forced swim test – a rodent model of depression (62). This response was compared to suicidal behavior because the diminished motivation state was fully corrected with antidepressant drugs and clozapine (63), established treatments used in suicide prevention (64–68). Diminished motivation to search for food results from imbalances in serotonergic and cholinergic function (59).

Recently, animals with defects in genes implicated as risk factors for suicide (including orthologs of STK33, HIPK2 and DCC mentioned above) showed the same diminished motivation phenotype that was also corrected with antidepressants and clozapine (D.S.D., unpublished observations). These risk factors have not been thoroughly characterized in humans and their roles are likely to be complex. We have already gained a relevant foothold in *C. elegans*. Moreover, the relative simplicity of this system may allow us to establish mechanistic connections to counterparts of human suicidal behavior that would otherwise be overlooked.

At first glance, it may seem farfetched to consider the foraging response of *C. elegans* informative with respect to motivation to commit suicide. However, all animals must acquire food to live, and by not engaging in foraging the mutant strains are not engaging in life. It would be fitting that investigation of a behavior necessary to sustain life might also provide insight into self-inflicted behaviors to end it.

C. elegans must assess and respond to threats in the environment. Genetic mutations can produce an overly keen sense of threat in response to perceived levels of ambient O_2 that causes animals to aggregate or "social feed" on bacterial lawns (69, 70). This phenotype is prominent in strains with defects in the neuropeptide Y receptor (*npr-1*) gene (69). This receptor signaling pathway is involved in anxiety in rodents and man (71–73) and has been identified as a risk factor for suicide (23–25). *C. elegans* strains with loss-of-function mutations in the 3-phosphoinositide dependent kinase-1 (*pdk-1*, mentioned earlier) also show aggregation (social feeding) that is corrected with clozapine and lithium (D.S.D., unpublished observation); the latter drug is also effective in decreasing suicidal behavior (74–76). Consequently, we wonder if exaggerated threat assessment in man may be regulated in a similar way. An exaggerated threat response would allow common events such as changes in social status to be perceived as existential threats and crises. By studying the genetics and mechanisms that cause exaggerated threat assessment in *C. elegans*, we may obtain insights into similar processes in persons with STBs.

The last reactant that will be discussed here is impulsivity. Impulsivity sits at the crossroads of logic and emotion. It is involved in the cognitive control of stay vs. go decisions that select between psychomotor programs specifying incompatible and/or opposing actions. An animal can stay and eat or go and forage, but cannot do both at once. Similarly, a person can be logical and analytical or emotional and impulsive, but cannot be both simultaneously. Brain circuitry controls which of the opposing actions will be selected and implemented. In *C. elegans*, we identified such a circuit, called a counter-circuit, involving two sets of dopaminergic neurons that control opposing actions (63). The sets of neurons receive different inputs and send collateral processes to regulate the other pathway. The dopaminergic neurons bear D2-type dopamine receptors such that when one dopaminergic pathway is active, it releases dopamine that suppresses the other pathway *via* the D2 receptors, thus preventing the opposing action. We suggest that impulsivity and logic are regulated by similar circuitry in humans (63) and in fact, dopaminergic projections to the

limbic system and frontal cortex appear to have a counter-circuit arrangement involving collateral processes and D2 receptors (77–79). According to the model, impulsivity created by an excess of limbic activity (an overly simplistic view) causes opposition override of logical input from the frontal cortex in a counter-circuit. Finally, religious beliefs or strong ideology can perform the same function *via* a counter-circuit and override opposition (e.g., fear of death or moral objections) to becoming a suicide bomber.

The fundamental behaviors discussed in this section overlap with some of the endophenotypes for STBs proposed by others, namely hopelessness, serotonergic dysfunction and impulsivity (50, 51). Therefore, basic components of suicidal ideation and behavior are evolutionarily conserved, which means animal models may provide useful insights even if they fail to fully recapitulate suicide. Moreover, the work in *C. elegans* shows mechanistically how variation in suicide risk genes can produce endophenotypes such as diminished motivation that are potentially relevant for suicidal behavior.

ADVANTAGES AND LIMITATIONS OF THE MODEL

The main advantage of the catalytic reaction model is that it integrates what is known about the genetics and brain circuitry of suicidal behavior with established risk factors including hopelessness (diminished motivation), existential crises (exaggerated threat assessment) and impulsivity (opposition override) to provide biological foundations and/or explanations for STBs. By conceiving of suicide as a semi-reversible catalytic reaction where suicidal thoughts and genetic risk catalyze planning, attempts and suicide, the model reflects a dynamic continuum of behaviors rather than discrete stages affected by different factors. Moreover, the concept of multiple factors (reactants) contributing to the overall reaction negates the need to ascribe single or limited sets of reactants (e.g., hopelessness or thwarted belongingness) as the most important causative factors to the exclusion of others. Suicidal behavior is a changeable process anyway, so the greatest concerns and driving forces during early stages of developing suicidal ideation may be different from the major factors that tilt the balance toward action at a later time. The reversible nature of the reaction can also explain why only a fraction of those with suicidal ideation actually commit suicide. Although suicidal thoughts are an effective catalyst for suicide, the reactants and response conditions (altered socioeconomic status, decline in general health, ACEs, etc.) must together achieve a critical mass for the reaction to proceed.

The theory includes many testable components and encourages exploration of how genes affect phenotypes representing fundamental behaviors that normally sustain life. It also can account for gene-environment interactions that unfold as conditions change or new reactants arise. Finally, although suicidal ideation emerges from thoughts of hopelessness or inescapable harm, override of opposition (e.g., survival instincts or moral compunction) is an important feature of the model

and may be mediated by impulsivity or strong ideological motivation. For example, a suicide bomber may perceive an outside, existential threat to their way of life that can only be met with extreme self-sacrifice.

Every theory of suicide potentially advances our knowledge, but there may be limitations too. The present model is wide in scope and highlights dynamic aspects of the process (similar to the FVT), which is attractive from a descriptive standpoint, but makes it more difficult to delineate the precise role of the reactants. Another potential limitation concerns the best way to narrow focus on those factors that will allow accurate prediction of suicidal intent in order to initiate prevention strategies. We have spotlighted several of what we view to be the most salient factors here; however, these are subject to bias. It is also plausible that suicide is inherently a chaotic process reflecting the state of mind of someone considering it, and this process, by definition, may resist full characterization and elude predictability. Chaotic processes contribute to the liability for psychiatric disorders (80), therefore this possibility merits serious consideration. Any model of suicide will be subject to this last limitation.

ENVIRONMENTAL CONDITIONS OF THE REACTION: STRESS AND RELATED FACTORS

The model suggests that stressors contribute significantly to the conditions that determine suicidal reactions. Two aspects will be covered here: (1) the general role of stress and (2) a specific example drawn from ongoing events – the COVID-19 pandemic. Stressors such as psychiatric disorders and challenging life events (e.g., medical illness or divorce) are important risk factors for suicide (81). Psychosocial crises and psychiatric disorders may constitute the stress component of the stress-diathesis models of suicidal behavior (29). The exposure to repeated acts of abuse and other adverse childhood experiences significantly increases risk of suicidal behavior throughout a person's life (82).

The involvement of stress in suicide permeates all the way to the molecular level. Maternal deprivation in infant rats causes changes in DNA methylation and expression of glucocorticoid receptor genes, leading to impaired feedback inhibition and ultimately elevated release of cortisol during an overactive stress response in adults (83, 84). Cortisol is the primary effector hormone of the HPA axis stress response system. Blunted cortisol responsiveness to stress (low baseline levels) is associated with suicide attempt in adults (85), possibly reflecting an adaptive response in the stress system. In addition, a lower baseline level of cortisol was identified as a potential trait that confers vulnerability to suicidal behavior (86, 87). By contrast, Giletta et al. (88) found that heightened cortisol reactivity during a psychosocial stress task was the strongest predictor of suicidal ideation at 3-month follow-up in at-risk adolescent females. This suggests that biological mediators of the stress response impact suicide risk and may augment the effects of exaggerated threat assessment and diminished motivation.

Current evidence supports the notion that vulnerability to STBs is continuous. Each time suicidal behavior is activated, it

becomes increasingly accessible in memory and requires fewer triggering stimuli to become activated the next time (89). This learned component of suicidal behavior may help to explain why people differ in their reactions to similar stressful life events spanning from disappointment and depression to deliberate self-harm and completed suicide (89).

In view of these connections between stress and suicide, the recent emergence of COVID-19, a life-threatening and chronic stressor, is cause for concern. Already, COVID-19 has been shown to adversely affect mental health by generating reactants such as loneliness and hopelessness with the rise in the number of cases (90–92). Additionally, the implementation of lockdown and business closings have caused social isolation and feelings of disconnection, which have exacerbated pre-existing mental health issues (92, 93). Social isolation has been associated with increased loneliness, anxiety, depression and early death (94). Moreover, social isolation exacerbates suicidal ideations, causing a detachment from support systems along with an increased risk of suicide (95, 96). The COVID-19 pandemic has also caused financial stress, which can create hopelessness, lower self-worth and increase mental health problems including suicidal ideation – the major catalyst in our model (96–98).

A recent US survey found that 45% of adults reported COVID-19 had caused immense worry and stress and negatively impacted their overall mental health (91). Furthermore, the pandemic has been linked to increased levels of substance use (90). Together, these COVID-19-related stressors increased suicidal ideation, suicide attempts and completed suicides (99–102). These observations held true for most age groups. The Coronavirus certainly qualifies as an existential threat, consistent with our model. Moreover, the resultant lockdowns and social distancing unintentionally spawned reactants in the form of social isolation, hopelessness and diminished engagement in enjoyable life activities. Thus, a major effect of COVID-19 and its associated stressors has been to increase the concentrations of catalysts and reactants available to promote an untoward reaction.

IMPLICATIONS FOR PREVENTION OF SUICIDE AND TREATMENT OF STBS

The view of how STBs manifest and evolve will affect strategies aimed at prevention of suicide and treatment of at-risk individuals. Accurate prediction of who is likely to attempt suicide is both a major challenge and key to prevention (4). The objective is to ascertain where a person with suicidal ideation stands in the reaction scheme proposed here, i.e., are there sufficient catalysts and reactants to drive a behavioral response toward attempted or completed suicide? Modifiable factors include the presence of a psychiatric condition, substance use, hopelessness, aggressive/impulsive tendencies, isolation/loneliness, loss, and an underlying medical condition (43, 103–105). In addition, cultural and religious beliefs may support the notion that suicide is acceptable or respected (106, 107). Non-modifiable "conditions" include male gender, older age (especially with infirmity), white or native American race, history of ACEs, and suicide in a family member or close friend

(43, 103–105). Recent or current hospitalizations are a strong risk factor for suicide (108); however, most suicides are completed by individuals who have not been hospitalized (104). Consequently, numerous factors must be evaluated and altered to effectively interrupt the suicidal reaction.

Previous work has suggested the following approaches could be used to prevent suicide: education programs for the general public and professionals, treatment of existing psychiatric conditions, changes to media reporting of suicide, restriction to access of lethal means, and screening methods, especially for those at high risk (109, 110). Meta-analyses support the efficacy of restricted access to lethal means, education programs for physicians and school-age children and cognitive behavioral therapy [CBT; (109, 110)]. Moreover, there is evidence in adolescents to suggest that multilevel prevention programs can help prevent suicide. The Nuremberg Alliance Against Depression is the best-evaluated intervention and included cooperation with primary care providers, a professional public relations campaign, training community facilitators, and self-help groups. This intervention resulted in a 24% reduction in suicidal acts (111). Altogether, these prevention strategies will increase awareness of risk factors for suicide, reduce the severity of reactants, such as hopelessness and isolation, and increase the barrier to suicide.

When evaluating a patient for STBs, it is critical to establish whether there is a cogent plan along with access to lethal means or a history of previous attempts and recent disengagement in life activities such as interactions with family and friends. Upon completing of the evaluation, the clinician should gauge the patient's disposition and decide whether hospitalization is necessary, and effectively address any existing psychiatric conditions. Finally, stressors should be targeted, triggers of STBs should be avoided, and family and friends should be involved in the process.

From a pharmacological standpoint, studies support the use of clozapine and lithium to reduce suicide risk in appropriately targeted populations (66, 74–76, 112). For example, clozapine significantly decreased suicide attempts in patients with schizophrenia and schizoaffective disorder (66, 112). In addition, lithium reduced the risk of suicide in patients with bipolar disorder and major depression (74–76). In a previous section, we discussed how these drugs modify behavioral counterparts of STBs in model organisms. Antidepressant drugs have a role in addressing symptoms of depression in at-risk individuals; however, they offer less benefit in suicide prevention (110). In fact, some studies have shown antidepressants may increase STBs especially in children, adolescents and young adults (113–115). We suggest that clozapine and lithium may address the neurobiological processes underlying overactive threat assessment, diminished motivation to engage in life and selection between opposing behaviors.

CONCLUSIONS

The CRM offers a novel view of suicide and the driving forces behind it. Because many different reactants that vary in intensity, frequency and duration contribute to STBs along with changing environmental conditions, it should be possible to interrupt

suicidal behavior at different points and with different strategies. The overall approach would be to change reaction conditions and the energy/intensity of reactants to reduce the catalytic activity of suicidal ideation. A primary goal would be to train individuals with STBs to self-monitor and identify states of mind in order to regulate reactants (especially impulsivity/emotionality and symptoms) and restore low catalytic activity and safety. At the same time, mindfulness and cognitive behavioral skills (including dialectical behavioral therapy [DBT] and CBT for suicide prevention), aimed at identifying cognitive distortions, can enhance appreciation that perceived threats can be effectively managed. Furthermore, if individuals with suicidal ideation are introduced to the concept that suicidal behavior is a dynamic process rather than a predictable path or inevitable solution, they may be more willing to collaborate in developing a treatment plan to address the conditions and reactants and ultimately exert control over the catalyst. Encouraging greater engagement in life activities and involvement in social interactions or advancing the greater good of society will instill positive goal-directed behavior that redirects from suicidal ideation. Through the CRM process, current status and likelihood for action would be evaluated, while affording the person agency to project themselves into the future in the context of both positive and negative changes in reactants and conditions and to master these forces. In therapy, the CRM process would promote extrapolating behavior to visualize new life trajectories, self-monitoring and the use of regulating skills leading to the inception of hope. It is important that the person understands that reactants will not completely disappear, but can be reduced and managed with psychoeducation, learning and practice, which builds self-esteem and self-efficacy. Collectively, these prevention strategies would decrease the catalytic activity of suicidal ideation, raise the energy barrier to suicidal behavior and provide alternative reaction pathways with positive outcomes.

AUTHOR CONTRIBUTIONS

DD conceived of the topic and major ideas, wrote, and edited the paper. PM, SS, AS, and WT contributed to the writing, editing, and revision of the manuscript. All authors contributed to the article and approved the submitted version.

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Teen Advisory Council Survey's Factors Associated With Self-Harming Thoughts

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Background: The evaluation of teens with self-harming thoughts (SHT) is a high-stakes task for physicians in community and emergency department (ED) settings. The lived experience of adolescents with stress and SHT provides an important source of insight for mental health professionals who evaluate and treat teens A snapshot of the lived experience of teens in northwest Louisiana was captured by the Step Forward Teen Advisory Council (TAC) in 2019. The TAC surveyed peers with the goal of identifying common stressors experienced by local teens in order to inform policy and practices in the local school system. The identification of stressors is a critical step in addressing SHT as adolescents who experience life stressors are at increased risk for self-harming thoughts (SHT), a known precursor to self-harm and suicide. Assessing youth for life stressors is a critical element of suicide prevention.

Methods: Local teens queried 5,070 peers attending Caddo Parish schools to better understand the stressors faced by high school students in Northwest Louisiana using a student developed survey. Results were presented to peers at a virtual summit where teens developed action items to reduce stress and presented findings to local leaders. Their efforts ultimately lead to increased supports for students in local schools.

Results: Over half of the teens surveyed reported stressors that negatively impacted their physical or emotional well-being. Students endorsing self-harming thoughts reported an average of 7.82 stressors as compared to 3.47 in peers without SHT. Teens with stressors at both home and school were more likely to experience SHT than teens with stressors in a single location.

Conclusion: The Gen Z students who developed the TAC Survey identified stress as a major concern for teens in Northwest Louisiana. The TAC Survey data aligns local experience with established data regarding the association between stress, depression

and SHT. Second, the results highlight the importance of diving deep to identify all stressors when assessing the risk of self-harm. Finally, the lived experience of local teens with SHT provides critical information for professionals to better understand risk for SHT and suicide in our region and beyond.

INTRODUCTION

The evaluation of teens with self-harming thoughts (SHT) is a high-stakes task for physicians in community and emergency department (ED) settings. ED visits related to SHT doubled nationally between 2007 and 2015 (1, 2). Rates of suicidal ideation (SI) increased in March through July 2020 as compared with 2019; however, rates were significant only in March and July (3). During the pandemic, emergency departments have experienced a marked increase in visits by teens related to suspected suicide attempts, with a 50.6% increase for girls and a 3.7% for boys in 2021 compared to 2019 (4).

Self-harming thoughts (SHT), including but not limited to suicide ideation (SI), are a precursor to self-harm and suicide, the second leading cause of death for youth between the ages of 12–18 years (5). Reports of the lifetime prevalence of SI among adolescents range from 9.6 to 39.4% with increased prevalence noted among specific subgroups, including LGBTQ youth and females (6–9). The rate of SI among LGBTQ adolescents exceeds that of peers, with 42% endorsing SI compared to 14% for those non-identifying youth in a study of nearly 5,000 teens (10). Furthermore, the rate of SI for females is twice that of males (11, 12). Despite a slight overall decrease in self-reported suicidal ideation (SI) between 2015 and 2017, SI remains common with a weighted overall prevalence rate of 18.8% among high school students between 1991 and 2017 (13). Alarmingly, Caddo Parish data does not reflect this trend. According to the Caring Communities Youth Survey, SI increased by 19% among 10th graders and a 27% among 12th graders between 2016 and 2020 (14).

The United States Surgeon General's 2021 *Call to Action to Implement the National Strategy for Suicide Prevention* (15) highlights the importance of screening for SHT. While the presence of a mental disorder is up to 90% in persons who die by suicide, adolescence is a time when mental disorders often emerge. This fact supports the importance of screening for symptoms and identifying emerging mental illness in youth with SHT in order to prevent suicide (16). Psychosocial factors contributing to suicide risk include being bullied, child abuse, stressful life events, and suicide contagion (17–20). Teens lived experience with bullying, abuse, and stress were factors that were also included in the Teen Advisory Council's survey.

Assessing SHT requires query into many factors including symptoms of mental illness, risk and protective factors, and psychosocial stressors. Symptoms of mental illness that are correlated with SHT include depressed mood, anxiety, hopelessness, social isolation, eating disorders, and substance use (9, 21–24). Support from family and friends is protective against SHT, especially for girls (25). Lower parent-family connectedness has been reported among sexual minority youth, a population at increased risk for SHT (26). School connectedness has also been identified as a protective factor in reducing suicide risk (27, 28). Beliefs surrounding help-seeking may moderate the progression of SHT to a suicide attempt (10). The assessment of suicide risk balances symptoms of mental disorders, risk factors, and psychosocial stressors against protective factors to design individualized safety and treatment plans. Knowledge of local trends in SI, youth stress, and youth supports is critical if clinicians are to protect youth.

Methods

Step Forward is a community organization in Northwest Louisiana working to intentionally address complex problems in the local community. Specifically, they aim to ensure success for every child from cradle to career. To further this goal, the Step Forward Teen Advisory Committee (TAC) was established in the spring of 2019 to allow local teens to share their knowledge and perspectives regarding the needs of local youth. The TAC served as expert advisors to Step Forward community leaders in to identify key focus areas and to develop action plans aimed at improving outcomes for all teens in Northwest Louisiana. These young leaders identified three key objectives: improve teen mental health, increase diverse career training opportunities, and increase youth civic involvement. Improving teen mental health became the primary focus of the TAC.

With the goal of formulating a strategic plan to improve teen mental health, the TAC first sought to establish a baseline for Teen Mental Wellness in the region through a survey. The TAC survey consisted of 15 questions concerning students' age, gender, parish of residence, and stressors that they may have faced or were facing at the time. Additional questions focused on feelings of belonging, engagement with their school and community, and social media usage. The survey questions were reviewed by a professional mental health evaluator for scope and language use, specifically to focus on wellness rather than mental illness.

The local school superintendent approved survey before it was distributed through an online platform, SurveyMonkey. All students in attending public high schools in Northwest Louisiana were invited to participate individually and during their English classes from mid-December 2019 to mid-January 2020. The survey received 5,070 student responses with student ages ranging from 14 to 19 years. While all high school students were invited to participate, most respondents (4,989) were from the Caddo Parish School District due to the robust support from the superintendent. The data received was first analyzed

TABLE 1 | Table of characteristics stratified by self-harm thoughts.

	Total Sample	No	Yes	p-value
	N = 3,640	N = 3,134	N = 506	
Age (years), mean (SD)	15.78 (1.22)	15.79 (1.22)	15.73 (1.22)	0.27
Gender				<0.001
Other	60 (1.6%)	38 (1.2%)	22 (4.3%)	
Female	2,161 (59.4%)	1,780 (56.8%)	381 (75.3%)	
Male	1,374 (37.7%)	1,284 (41.0%)	90 (17.8%)	
Prefer not to say	45 (1.2%)	32 (1.0%)	13 (2.6%)	
Stressors faced by students				
Anxiety				<0.001
No	1,727 (47.4%)	1,641 (52.4%)	86 (17.0%)	
Yes	1,913 (52.6%)	1,493 (47.6%)	420 (83.0%)	
Depression or Extreme Sadness				<0.001
No	2,051 (56.3%)	1,988 (63.4%)	63 (12.5%)	
Yes	1,589 (43.7%)	1,146 (36.6%)	443 (87.5%)	
Hallucinations				<0.001
No	3,488 (95.8%)	3,048 (97.3%)	440 (87.0%)	
Yes	152 (4.2%)	86 (2.7%)	66 (13.0%)	
Loneliness				<0.001
No	2,243 (61.6%)	2,102 (67.1%)	141 (27.9%)	
Yes	1,397 (38.4%)	1,032 (32.9%)	365 (72.1%)	
Mood swings				<0.001
No	2,026 (55.7%)	1,881 (60.0%)	145 (28.7%)	
Yes	1,614 (44.3%)	1,253 (40.0%)	361 (71.3%)	
Stress				<0.001
No	1,048 (28.8%)	992 (31.7%)	56 (11.1%)	
Yes	2,592 (71.2%)	2,142 (68.3%)	450 (88.9%)	
Number of stressor types, mean (SD)	4.08 (3.00)	3.47 (2.28)	7.82 (4.04)	<0.001
Location of personal stressors				
Your Home				<0.001
No	1,153 (31.7%)	1,083 (34.6%)	70 (13.8%)	
Yes	2,453 (67.4%)	2,018 (64.4%)	435 (86.0%)	
Missing values	34 (0.9%)	33 (1.1%)	1 (0.2%)	
School				<0.001
No	613 (16.8%)	563 (18.0%)	50 (9.9%)	
Yes	2,993 (82.2%)	2,538 (81.0%)	455 (89.9%)	
Missing values	34 (0.9%)	33 (1.1%)	1 (0.2%)	
Person who students confided with				
Parent				<0.001
No	1,170 (32.1%)	933 (29.8%)	237 (46.8%)	
Yes	1,134 (31.2%)	999 (31.9%)	135 (26.7%)	
Missing values	1,336 (36.7%)	1,202 (38.4%)	134 (26.5%)	
Teacher				<0.001
No	2,046 (56.2%)	1,739 (55.5%)	307 (60.7%)	
Yes	258 (7.1%)	193 (6.2%)	65 (12.8%)	
Missing values	1336 (36.7%)	1,202 (38.4%)	134 (26.5%)	
School counselor				<0.001
No	2,089 (57.4%)	1,792 (57.2%)	297 (58.7%)	
Yes	215 (5.9%)	140 (4.5%)	75 (14.8%)	
Missing values	1,336 (36.7%)	1,202 (38.4%)	134 (26.5%)	

(Continued)

TABLE 1 | Continued

	Total Sample	No	Yes	p-value
	N = 3,640	N = 3,134	N = 506	
Things would not get better				<0.001
No	1,426 (39.2%)	1,303 (41.6%)	123 (24.3%)	
Yes	878 (24.1%)	629 (20.1%)	249 (49.2%)	
Missing values	1,336 (36.7%)	1,202 (38.4%)	134 (26.5%)	
Was confiding in someone beneficial?				<0.001
No	506 (13.9%)	375 (12.0%)	131 (25.9%)	
Yes	1,798 (49.4%)	1,557 (49.7%)	241 (47.6%)	
Missing values	1,336 (36.7%)	1,202 (38.4%)	134 (26.5%)	
Engagement in school, extracurricular, or community activities				0.026
No	1,040 (28.6%)	873 (27.9%)	167 (33.0%)	
Yes	2,477 (68.0%)	2,150 (68.6%)	327 (64.6%)	
Missing values	123 (3.4%)	111 (3.5%)	12 (2.4%)	

TABLE 2 | Odds ratio for reporting self-harm thoughts.

	OR	95% CI	P-value
By gender			
Male (Ref)	1	–	–
Female	3.05	2.40 to 3.88	< 0.001
Other	8.26	4.69 to 14.56	< 0.001
Prefer not to say	5.80	2.94 to 11.43	< 0.001
By location of personal stressors			
Not at School or Home (Ref)	1	–	–
Only at School	0.88	0.49 to 1.59	0.677
Only at Home	1.39	0.74 to 2.60	0.306
Both at School and Home	3.36	1.97 to 5.74	< 0.001
Engagement in school, extracurricular, or community activities	0.79	0.63 to 1.00	0.05

through SurveyMonkey and then transferred to Microsoft Excel for further analysis by the TAC for presentation to area leaders. Analysis for this article was performed using STATA/BE v17 (StataCorp, LLC). Continuous variables are presented as mean (SD). Categorical variables are presented as the number (proportion or %) of participants. P-values for continuous variables correspond to Two-sample T-test (for comparison of means between groups). P-values for categorical variables correspond to Pearson's $\chi 2$ tests. Univariate logistic regression models were used to identify predictors to estimate the odds of the outcome of student variables in relation to SHT.

During the 2019–20 school year, there were 11,248 students enrolled in ten public high schools in Caddo Parish. The demographics of Caddo Parish at this time were characterized by 71% minority populations with 29% being White. 49.52% were female and 50.48% were male with 69.9% considered economically disadvantaged. Population per grade was 9th−3,156; 10th−2,802; 11th−2,666; 12th−2,624.

RESULTS

Participants

Respondents to the Teen Mental Wellness Survey included 5,070 Louisiana public high school students in Bossier, Caddo, and Red River parishes, with 98.4 percent of respondents residing in Caddo Parish. The average age for respondents was 15.79 years. Female students were more prevalent in this sample (54.3%) followed by males (43.5%), "Other gender" (1.3%), and "Prefer Not to Say" (1%) (**Table 1**).

Self-Harm by Gender

Some genders were more likely to endorse SHT as a stressor. Female (OR = 3.05; 95% CI = 2.40–3.88), Other Gender (OR 8.26; CI 4.69 to 14.56), and Prefer Not to Say Gender (OR = 5.80; 95% CI = 2.94–11.43) students had a substantially increased risk of endorsing SH as a stressor (**Table 2**).

Stressors Faced by Students With SHT

Students who endorsed SHT as a stressor also were at much greater risk for other stressors, including Stress (OR = 3.72; 95% CI = 2.79–4.96), Mood Swings (OR = 3.74; 95% CI = 3.04–4.59), Loneliness (OR = 5.27; 95% CI = 4.28–6.49), Hallucinations (OR = 5.32; 95% CI = 3.80 to 7.44), and Anxiety (OR = 5.37; 95% CI = 4.21–6.84). The stressor with the greatest co-occurring risk for SHT was Depression or Extreme Sadness (OR = 12.20; 95% CI = 9.28–16.04). The average number of stressors was also significantly different revealing that SH was included in an average total of 7.82 stressors as compared to 3.47 (OR = 1.58; 95% CI 1.52–1.65) total stressors for students who did not endorse SHT. Students endorsing SHT were also significantly more likely to believe that things would not get better (OR = 4.19; 95% CI = 3.31–5.31) (**Figure 1**).

Location of Personal Stressors

Location of personal stressors, whether home or school, did not reveal a significant difference for students with the stressor of SHT. However, when stressors occurred in both places
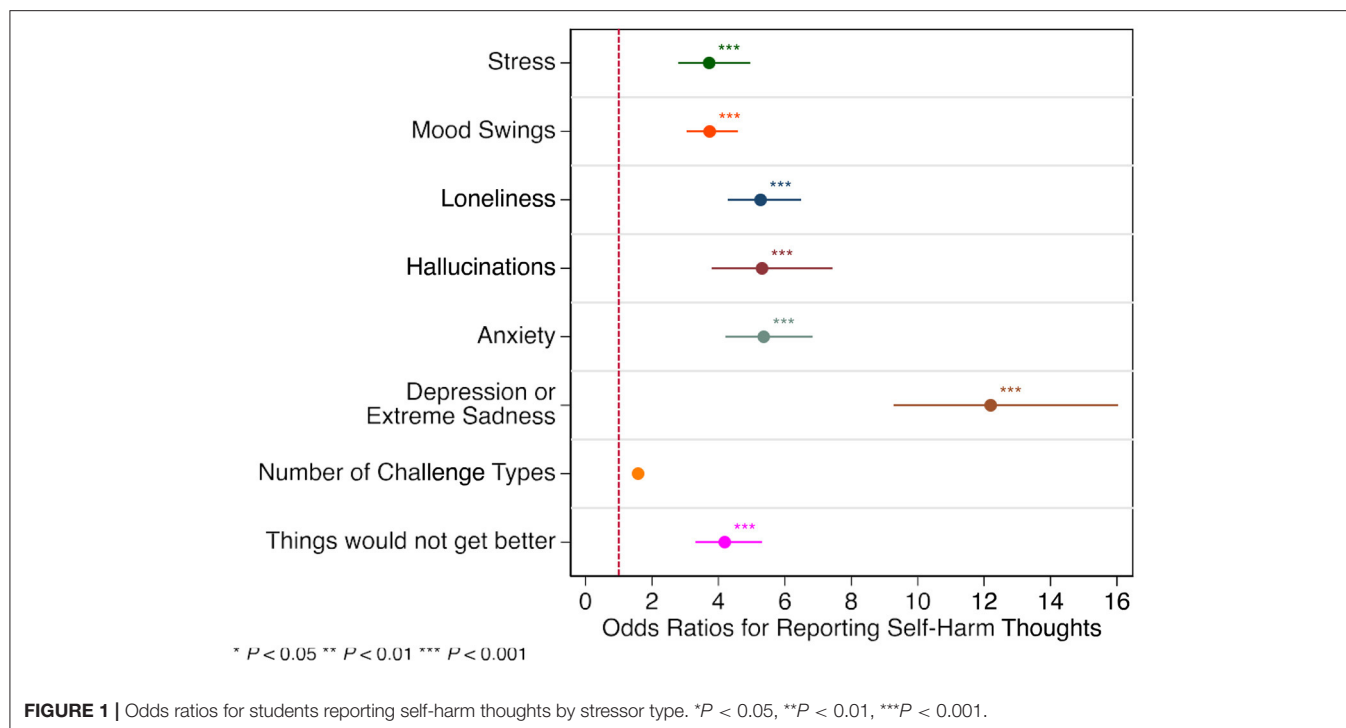
FIGURE 1 | Odds ratios for students reporting self-harm thoughts by stressor type. *P < 0.05, **P < 0.01, ***P < 0.001.

TABLE 3 | Odds ratios for finding confiding in someone beneficial among students who reported self-harm thoughts.

	OR	95% CI	*P*-value
Confiding in Teacher	1.17	0.6–2.07	0.589
Confiding in School Counselor	1.03	0.61–1.75	0.911
Confiding in Parents	1.40	0.89–2.20	0.141

simultaneously, the risk for SHT was substantially greater (OR = 3.36; 95% CI = 1.97–5.74) (**Table 2**).

Other Factors

Students with the stressor of SHT had an associated risk for loneliness. Engagement in school, extracurricular, or community activities was significantly associated with a decreased likelihood of SHT (OR = 0.79; 95% CI= 0.62 to 1; $p = 0.05$) (**Table 2**). There were also no significant differences in the groups for the perceived benefits of confiding in a teacher or school counselor; however, those who endorsed SHT were more likely consider confiding in a parent to be beneficial (OR = 1.40; 95% CI = 0.89–2.20) (**Table 3**).

DISCUSSION

During patient care, the assessment of suicide risk is one of the most complex and challenging tasks faced by clinicians. Even the most experienced psychiatrists may long for a definitive assessment scale or additional patient information. In examining the lived experience of local high school students, this study provides a valuable additional data source. Namely, the importance of an exhaustive exploration of all stressors faced by the patient. During evaluations clinicians typically identify the most pressing stressor but it is the total stressor load that contributes to self-harm risk, particularly if stress is significant at both home and school.

The high school students who developed the TAC Survey identified stress as a major concern for teens in Northwest Louisiana. This was an astute choice. The TAC are members of Generation Z, persons born between 1997 and 2010. GenZers report a higher level of stress than other groups, and during the pandemic, GenZers have struggled the most. Fortunately, they are more likely to seek mental health services than others. As digital natives, they are at ease with online research, surveys, virtual meetings, and therapy. Many GenZers, like the TAC, are comfortable engaging leaders and leveraging data to promote change. The TAC embraced the concept that all health is local (29) and became influencers for change in our region, documenting their lived experiences and increasing awareness and access to mental health services in our schools.

While the TAC had systems change as a goal, their research yields important lessons for mental health professionals in three major ways. First, the TAC data confirms that our local experience aligns with established data indicating that depression and anxiety are associated with self-harm. Second, the importance of diving deep to identify stressors when assessing youth for suicide prevention is highlighted as ameliorating stressors is critical to minimizing the risk of self-harm. And finally, the experience of local teens with SHT provides critical information for professionals to understand risk in our area and beyond. This is critical knowledge given that SHT and suicide

by peers can promote contagion. While this study represents the lived experience of urban and rural teens in the southern United States, similar stresses are widely reported for adolescents, suggesting that the results found here would generalize to other locales (29).

The TAC data shows that symptoms of depression, anxiety, mood swings, and eating disorders are associated with SHT. The TAC study found young women to be at three times the risk for SHT compared young men, in contrast to the findings of Howarth et al. (19) that males were at greater risk than females. This highlights the fact that the assessment of suicide risk is informed by research but ultimately treatment decisions must be based on the presentation and needs of the individual patient. The self-report of symptoms of mental disorders by teens highlights the need for accessible and comprehensive mental health services. In fact, the TAC requested such from local governing bodies, including Bossier Parish Public Schools and Caddo Parish Public Schools. TAC provided the school districts with a list of policy recommendations, including increased interaction with school counselors, incorporating mental health content into health education classes, and education for teachers on the signs and symptoms of mental health disorders in youth. In addition to stress due to symptoms of mental illness, the TAC survey revealed that where stressors occur, the number of stressors is a significant predictor of SHT. A 2020 systematic review and meta-analysis found suicidal ideations were increased by 45% among persons reporting life stressors (19). The TAC data shows over three times the risk for SHT when stress is high at home and school compared to stress in a single setting. This highlights the importance of exploring life circumstances at home and school when assessing youth for SHT. Youth with SHT reported a higher number of stressors than those without SHT, with ranges of 5–11 and 3–5, respectively. This serves as a lesson to mental health professionals to seek to identify as many stressors as possible in order to construct the most beneficial safety plan possible by addressing each stressor specifically and identifying where the teen feels safe. If stressors are present in both school and home, the lack of a safe respite from one or the other may result in unrelenting distress during all waking hours. Life events scales can assist in identifying stressors, but a follow-up interview is necessary to understand the meaning of the stressful event to the adolescent in order to intervene appropriately (30).

Potential Limitations

This study is limited due to the use of a non-validated, self-report survey instrument. A standardized instrument would have resulted in greater generalizability and would have allowed more robust comparison to existing data on stress in teens. The TAC Survey was created by the TAC to promote system change rather than measure variables associated with SHT. It was not designed to be a scientific research instrument. By design, the instrument did not capture race, sexual orientation, or gender identity—all critical factors for understanding SHT and preventing suicide. Finally, this study examines the lived experience of American teens in northwest Louisiana, the generalizability to broader populations, while likely, is uncertain and bears further study.

Future Directions

The TAC Survey data identified the importance of comprehensive exploration of stressors as part of the overall assessment of SHT and Safety Planning. Each stressor represents a critical intervention point for suicide prevention. This finding has important implications for safety planning and the design of safety planning forms. The Warning Signs section of most Safety Plan templates captures stressors but does not encourage listing more than a few warning signs and does not explicitly indicate that location where the stressor is experienced should be documented (31). Constructing a Safety Plan in collaboration with the patient and family is the current standard of care. This study suggests that the failure to explore all stressors contributing to distress and hopelessness represents a missed opportunity for preventing death by suicide. Future research might explore the feasibility and benefits of expanding the Warnings Signs section when completing a collaborative Safety Plan with adolescents to capture 5–7 stressors that are warning signs. In this study, students with SHT experienced an average of 7.8 stressors. While understanding the most significant stressor is important, reducing the number of stressors could be just as beneficial and remains an area for future study.

The TAC Survey found that stressors in multiple locations can increase risk for SHT, highlighting the importance of a safe harbor as part of overall suicide prevention efforts. Providing parents, teachers, coaches, and others working with teens information on how to support teens and reduce stress in order to create a safe place is critical. Student advocacy has led some states and school districts to recognize mental health days as excused absences, creating a brief space free of academic stress (32). The impact of such efforts to reduce SHT is promising but bears further study. In addition to reducing the number of stressors, a therapeutic goal should be to establish a safe haven from distress. Safety planning should include discussion of places where the teen feels safe. Cyberspace, a locus without physical boundaries, as a source of both distress and a safe haven must also be considered. The influences of social media and gaming and teens strategies for recognizing and managing these influences must be understood for a given individual as part of safety planning to manage SHT.

Finally, the use of a teen-developed survey to leverage change across an entire school district with the subsequent presentation of the data at a regional suicide prevention summit and scientific publication of the data in multiple articles illustrates the power of teens to use their lived experience to change the world. The TAC experience has provided a source of hope and inspiration for those involved as mentors as we observed the student's ingenuity and progress with awe. We would challenge other communities to empower adolescents to identify needs and capture their own experience to inform medical care and broader community solutions for complex stressors.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

AUTHOR CONTRIBUTIONS

RL, JT, LA, PM, and JM contributed to the conception and design of the study. VA-Q performed the statistical analysis. PM, JT, and LA wrote sections of the article. KM, JP, and CS contributed to manuscript revision. All authors contributed to the article and approved the submitted version.

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Quality and quantity of serious violent suicide attempts during the COVID-19 pandemic

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Background: While repeated shutdown and lockdown measures helped contain the spread of SARS-CoV-2 during the COVID-19 pandemic, social distancing and self-isolation negatively impacted global mental health in 2020 and 2021. Although suicide rates did reportedly not increase during the first months of the pandemic, long-term data, and data on the quality of serious violent suicide attempts (SVSAs) are not available to date.

Materials and methods: Orthopaedic trauma patient visits to the emergency department (ED), ED trauma team activations, and SVSAs were retrospectively evaluated from January 2019 until May 2021 in four Level-I Trauma Centers in Berlin, Germany. SVSAs were assessed for suicide method, injury pattern and severity, type of treatment, and length of hospital stay.

Results: Significantly fewer orthopaedic trauma patients presented to EDs during the pandemic ($n = 70,271$) compared to the control ($n = 84,864$) period ($p = 0.0017$). ED trauma team activation numbers remained unchanged. SVSAs (corrected for seasonality) also remained unchanged during control ($n = 138$) and pandemic ($n = 129$) periods, and no differences were observed for suicide methods, injury patterns, or length of hospital stay.

Conclusion: Our data emphasize that a previously reported rise in psychological stress during the COVID-19 pandemic does not coincide with increased SVSA rates or changes in quality of SVSAs.

Introduction

The COVID-19 pandemic imposed an unprecedented burden on health care systems worldwide. To effectively slow down the spread of SARS-CoV-2, governmental authorities decreed lockdown and shutdown measures of various degrees and lengths during 2020 and 2021 (1). While patients suffering from COVID-19 impacted intensive care units and hospital services, individuals and communities were additionally challenged by a rise in depression, anxiety, and acute stress symptoms resulting from quarantine and social distancing measures (2). Consistent data from the U.S. and Europe demonstrated an initial deterioration in mental health during the first months of the pandemic in March and April 2020, followed by a considerable degree of recovery during June, July, and August 2020 (3–5). Whether or not alternating states of mental health and depression may have influenced harmful behavior and suicide attempts, concerned authors since the beginning of the pandemic (6, 7), especially in the light of reports on increased suicide rates during previous healthcare crises like the SARS outbreak in Hong Kong in 2003 (8, 9).

As data on suicide rates during the pandemic slowly emerged, geographic differences became apparent. For example, while suicide rates in a majority of western countries, including Germany (10), did not increase but remain stable or decrease (11), other studies reported a rise in suicide attempts and completed suicides during the first months of the pandemic in Nepal, Italy and South Korea (12–14).

Japan also reported a rise in suicide numbers during the second wave of COVID-19 infections, following an initial decline (15). Data from the U.S. further showed ethnicity-based shifts in suicide rates during the pandemic in Maryland (16) and Connecticut (17).

While nonviolent suicide attempts (poisoning or overdosing) represent the majority of index suicide attempts, violent suicide attempts (e.g., hanging, cutting or piercing, jumping from great heights) represent the majority of completed suicides (18). Violent suicide attempts are often tied to injuries of the musculoskeletal system and have a higher prevalence among men (19). They were previously linked to ambient temperatures and a lack of sunshine hours (20, 21).

While most available studies focus on the number of suicides during the COVID-19 pandemic, reports on suicide quality remain scarce. In this study, we evaluated serious violent suicide attempts (SVSAs), defined as violent suicide attempts that would have been potentially lethal had it not been for rapid and effective emergency treatment (22). SVSAs were analyzed for suicide method, injury severity, and concomitant treatment strategies during 14 months amid the COVID-19 pandemic and a preceding 14-month control period in four Level-I Trauma Centers in Berlin, Germany.

Materials and methods

Study design and setting

Context/places

This retrospective study was conducted at four medical centers that fulfill the Level-I Trauma Center criteria, defined by the American College of Surgeons (ACS) and the German Trauma Society (DGU) (23). As part of a network of five Level-I Trauma Centers in Berlin, Germany, the four participating centers provide full 24/7 in house trauma care for the German capital and its adjacent urban areas.

Patient sample and key dates

Absolute numbers for orthopaedic trauma patients, trauma team activations, and SVSAs admitted to the emergency departments (EDs) of the four participating Level-I Trauma Centers in Berlin, Germany, were retrospectively assessed. The following periods were defined as 14-month pandemic and control periods:

- January 1, 2019–February 29, 2020 (control).
- April 1, 2020–May 20, 2021 (pandemic; Figure 1).

On March 16, 2020, the German government and the federal states announced a first temporary shutdown of public life, including schools, universities, restaurants, and bars (24). After some restrictions were lifted during the summer of 2020, a second shutdown was imposed

FIGURE 1
Longitudinal time chart of analyzed periods and COVID-19 related shutdowns implemented in Berlin, Germany during 2020 and 2021.
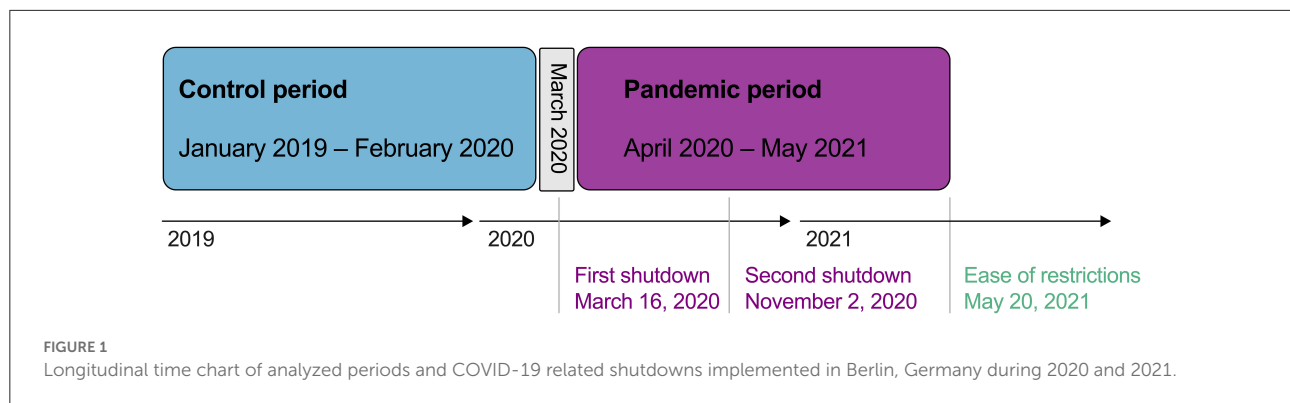
on November 2, 2020 (25). On May 20, 2021 shutdown measures were mostly lifted in Berlin, Germany, which marks the endpoint of the pandemic period in our analyses (Figure 1). March 2020 was excluded from the analyses to allow a clear discrimination between the control and pandemic period.

Sample frame and data collection

Investigators from each center retrieved data from hospital healthcare databases [retrospective chart review employing the convenience sampling approach (26)]. First, absolute numbers for orthopaedic trauma patients, trauma team activations, and SVSAs were evaluated. Second, all SVSA cases were reviewed in detail for parameters surrounding the quality of suicide attempts (Table 1). All patients were followed up until they were discharged from hospital or deceased.

Inclusion criteria

All orthopaedic trauma patients (defined as patients who were primarily treated by an orthopaedic trauma surgeon in the ED), and all cases where the trauma team was activated [initiated if patients met the Grade of Recommendation B-criteria (GoR-B) defined by DGU® (e.g. fall/jump from great heights, penetrating or gunshot injuries, high-velocity traffic accidents) (27)] were included. All SVSAs were included if the provided information in the medical chart indicated a suicide attempt or where a suicide intention leading to the injury could not be ruled out (e.g. in case of schizophrenia or bipolar disorder).

Exclusion criteria

For orthopaedic trauma patients and trauma team activations no exclusion criteria were required. For SVSAs we excluded patients who denied suicidal intentions and where an unintentional accident was plausible after ruling out mental health conditions.

Ethics

Ethical approval (EA1/082/20) was obtained from the local ethics committee, Ethikkommission Charité – Universitätsmedizin Berlin.

Statistical analysis

Data were analyzed primarily descriptively. Incidences were presented as absolute counts within the period of observation. For both the pandemic and the control period, specific characteristics of SVSAs were calculated and compared in an exploratory manner. In case of continuous and ordinal data, mean, median, interquartile range and standard deviation (SD) were calculated as well as the p-value from a Wilcoxon signed-rank test. For binary data, corresponding proportions were calculated as well as the p-value from Pearson's Chi-Squared test, or Fisher's exact test if the expected count in any cell was below 5. To compare variables during the pandemic vs. control period, odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. To allow for scale-independent comparisons between ORs of continuous variables, variables were standardized to a mean of 0 and an SD of 1.

A central aim of the analysis was the comparison of monthly incidences of SVSAs between the control and the pandemic period. To control for seasonal trends, a regression approach was chosen. The limited time period and the relatively small incidence raised concerns regarding the appropriate model fit of simple linear regression. Therefore, a sensitivity analysis also considering regression models for count data, i.e., poisson and negative binomial regression were fitted, too, and the results of each regression approach were compared.

All observations during the defined time frame within the participating Level-I Trauma Centers were included in the analysis, so no sample size calculation was conducted. Instead, an exemplarily power analysis was used to justify the chosen time frame: based on the assumption of a monthly incidence of ~10 SVSAs, the 95% CI of the pairwise difference between pre-

TABLE 1 Characteristics of patients who committed serious violent suicide attempts (SVSAs) during a 14-month COVID-19 pandemic period and a 14-month control period in Berlin, Germany.

Characteristic	Control, $N = 138$[1]	Pandemic, $N = 129$[1]	p-Value[2]
Hospital I	52 (38%)	45 (35%)	0.2
Hospital II	28 (20%)	21 (16%)	
Hospital III	17 (12%)	28 (22%)	
Hospital IV	41 (30%)	35 (27%)	
Female	45 (33%)	51 (40%)	0.2
Male	93 (67%)	78 (60%)	0.2
Age	43.0 (32.0, 58.0)	40.0 (28.0, 56.0)	0.2
Alcohol consumption	19 (14%)	15 (12%)	0.6
Drug consumption	19 (14%)	27 (21%)	0.12
Regular substance abuse	32 (23%)	36 (28%)	0.4
Psychiatric diagnosis	93 (67%)	79 (61%)	0.3
Jump from great height	56 (41%)	55 (43%)	0.7
Height	10.0 (5.5, 13.0)	9.0 (6.0, 14.0)	0.7
Train collision	16 (12%)	10 (7.8%)	0.3
Traffic collision	4 (2.9%)	1 (0.8%)	0.4
Cutting/piercing	41 (30%)	44 (34%)	0.4
Strangulation	5 (3.6%)	9 (7.0%)	0.2
Other methods	8 (5.8%)	4 (3.1%)	0.3
>1 method	8 (5.8%)	6 (4.7%)	0.7
Face	17 (12%)	20 (16%)	0.5
Skull	15 (11%)	11 (8.5%)	0.5
Clavicle	8 (5.8%)	5 (3.9%)	0.5
Humerus	17 (12%)	19 (15%)	0.6
Olecranon	3 (2.2%)	6 (4.7%)	0.3
Radius/Ulna	17 (12%)	17 (13%)	0.8
Hand	8 (5.8%)	6 (4.7%)	0.7
Ribs	35 (25%)	35 (27%)	0.7
Sternum	9 (8.2%)	10 (9.3%)	0.8
O-C spine	7 (5.1%)	5 (3.9%)	0.6
C spine	10 (7.2%)	6 (4.7%)	0.4
T Spine	25 (18%)	22 (17%)	0.8
L Spine	34 (25%)	33 (26%)	0.9
Sacrum	20 (14%)	17 (13%)	0.8
Pelvis	35 (25%)	31 (24%)	0.8
Femur	18 (13%)	21 (16%)	0.5
Tibia/Fibula	18 (13%)	28 (22%)	0.061
Patella	1 (0.7%)	5 (3.9%)	0.11
Foot	30 (22%)	29 (22%)	0.9
Open fracture	36 (26%)	18 (14%)	0.014
Excessive hemorrhage	25 (18%)	16 (12%)	0.2
Amputation	6 (4.3%)	1 (0.8%)	0.12
Pharynx/Trachea	6 (4.3%)	4 (3.1%)	0.8
Neck arterial vessel	5 (3.6%)	4 (3.1%)	>0.9
Pneumothorax	38 (28%)	35 (27%)	>0.9
Hematothorax	15 (11%)	18 (14%)	0.4

(Continued)

TABLE 1 Continued

Characteristic	Control, $N = 138$[1]	Pandemic, $N = 129$[1]	p-Value[2]
Pulmonary contusion	30 (22%)	23 (18%)	0.4
Intrathoracal arterial vessel	3 (2.2%)	7 (5.4%)	0.2
Heart	4 (2.9%)	3 (2.3%)	>0.9
Liver	13 (9.4%)	17 (13%)	0.3
Spleen	14 (10%)	8 (6.2%)	0.2
Stomach/Bowel	9 (6.5%)	7 (5.4%)	0.7
Kidney	11 (8.0%)	7 (5.4%)	0.4
Peritoneum/omentum	9 (8.2%)	6 (5.6%)	0.4
Intraabd. art. vessel	7 (5.1%)	10 (7.8%)	0.4
Subdural haematoma	12 (8.7%)	9 (7.0%)	0.6
Subarachnoidal hemorrhage	13 (9.4%)	13 (10%)	0.9
Intracerebral hemorrhage/contusion	9 (6.5%)	5 (3.9%)	0.3
Injury Severity Score (ISS)	22.0 (8.0, 29.0)	17.0 (5.0, 34.0)	0.6
Surgical resucitation	2 (1.4%)	7 (5.4%)	0.094
Emergency surgery	86 (62%)	71 (55%)	0.2
Semi-elective surgery	12 (8.7%)	11 (8.5%)	>0.9
Elective surgery	7 (5.1%)	6 (4.7%)	0.9
Conservative treatment	22 (16%)	18 (14%)	0.6
ED treatment	9 (6.5%)	16 (12%)	0.1
Death in ED	6 (4.3%)	3 (2.3%)	0.5
Death in ICU	9 (6.5%)	12 (9.3%)	0.4
Death in operating theater	1 (0.7%)	4 (3.1%)	0.2
Discharged home	22 (16%)	26 (20%)	0.4
Transferred to other facility	100 (72%)	84 (65%)	0.2
Days spent in hospital	11.0 (3.0, 24.2)	6.5 (2.0, 21.0)	0.12
Days spent in ICU	5.0 (2.0, 12.0)	3.0 (2.0, 9.0)	0.049

C spine, cervical spine; ED, emergency department; ICU, intensive care unit; L spine, lumbar spine; ISS, Injury Severity Score; O-C spine, occipito-cervical spine; T spine, thoracic spine.
[1]n (%); Median (IQR).
[2]Pearson's Chi-squared test; Fisher's exact test; Wilcoxon rank sum test.

and post-pandemic months would have an expected width of 1.0 SVSA per month.

Results

Absolute numbers and seasonality

During the pandemic period, significantly fewer orthopaedic trauma patients presented to the ED during the pandemic

(n = 70,271) compared to the control (n = 84,864) period (p = 0.0017). Subgroup analyses confirmed this pattern for each center (hospital I, p = 0.0012; hospital II, p = 0.0017; hospital III, p = 0.0006; hospital IV, p = 0.0046; Figure 2A). Furthermore, the longitudinal development of orthopaedic trauma patients per month unveiled a decrease in cases, especially during spring and autumn 2020, when lockdown measures were in effect in Berlin, Germany (Figure 2B).

Trauma team activation numbers remained unchanged during control and pandemic periods, with 3.267 and 3.298 cases, respectively (Figure 2C). Although overall numbers of trauma team activation did not differ, decreases were observed during shutdown periods (Figure 2D). Lastly, SVSAs also remained unchanged when comparing control (n = 138) and pandemic (n = 129) periods (Figure 2E). Monthly SVSAs were evenly distributed between February 2019 and August 2020, followed by a slight decline between September 2020 and May 2021 (Figure 2F). Interestingly, SVSAs decreased in all hospitals during the pandemic period, apart from hospital III (CBF), where an increase, yet not significant, was observed (p = 0.1270; Figure 2E).

Controlling for seasons, linear regression (p = 0.427), poisson regression (p = 0.446), and negative binomial regression (p = 0.446) models showed no differences between control and pandemic periods.

Additionally, we compared two calendar-matched 12-month periods from April 2019-March 2020 (control II) to April 2020-March 2021 (pandemic II) and found similar results, where linear regression (p = 0.523), poisson regression (p = 0.595), and negative binomial regression (p = 0.595) models showed no differences between control II and pandemic II periods.

Quality of SVSAs

Demographics and suicide motivation

After assessing absolute numbers of SVSAs, changes in quality and severity of SVSAs during the control and pandemic period were evaluated. No relevant differences were observed between the two periods for all variables assessed (Table 1).

Women accounted for 33% (n = 45) of SVSAs during the control and for 40% (n = 51) of SVSAs during the pandemic period. The median (IQR) age was 43 (29;30) years during the control and 40 (28;31) years during the pandemic period. Alcohol and drug intoxications in association with SVSAs were observed during control (both 14%, n = 19) and pandemic (alcohol 12%, n = 15; other drugs 21%, n = 27) periods. Regular substance abuse was seen in 23% (n = 32) of cases during the control and in 28% (n = 36) of cases during the pandemic period.

During the control period, psychiatric diagnoses were evaluated for 67% (n = 93) and during the pandemic for 61% (n = 79) of patients committing SVSAs (Figure 3A and Table 1).

Methods of SVSAs

With 41% (n = 56) and a median (IQR) height of 10 (5.5;13) meters and 43% (n = 55) and a median height of 9 (6;14) meters, jumps from great heights were the most common suicide method observed during control and pandemic periods, respectively. Cutting and piercing injuries were seen in 30% (n = 41) and 34% (n = 33) of cases during the control and pandemic period. SVSAs including subway train collisions were observed in 12% (n = 16) of cases during the control and in 7.8% (n = 10) of cases during the pandemic period. Strangulations were evident in 3.6% (n = 5) of cases during the control and in 7.0% (n = 9) of cases during the pandemic period. SVSAs including more than 1 method were observed in 5.8% (n = 8) of cases during the control and in 4.7% (n = 6) of cases during the pandemic period (Figure 3A and Table 1).

Injury patterns following SVSAs

Please refer to Table 1 and Figures 3B, C for a detailed overview of osseus and non-osseus injury patterns. No relevant changes were observed apart from open fractures, which were seen significantly less often during the pandemic period with 14% (n = 18) compared to the control period with 25% (n = 36) (p = 0.014). In addition, the median (IQR) ISS during the control period was 22 (8, 31) compared to 17 (5, 32) during the pandemic period.

Treatment of SVSAs

Resuscitation surgery was performed twice during the control period and seven times during the pandemic period. Sixty-two percent (n = 68) and 55% (n = 71) of patients required emergency surgery and 8.7% (n = 12) and 8.5% (n = 11) semi-elective and 5.1% (n = 7) and 4.7 (n = 6) elective surgery during the control and pandemic period. Sixteen percent (n = 22) and 14% (n = 18) of patients were treated conservatively and 6.5% (n = 9) and 12% (n = 16) of patients received ED treatment during respective control and pandemic periods (Figure 3D and Table 1).

Outcomes following SVSAs

Six patients died in the ED, nine in the ICU and one in the operating theater (11.6%; n = 16) during the control period and three in the ED, 12 in the ICU and four in the operating theater during the pandemic period (14.7%; n = 19).

Sixteen percent (n = 22) of patients could be discharged to their homes during the control and 20% (n = 26) during the pandemic period. The remaining patients (72%; n = 100 during the control and 65%; n = 84 during the pandemic) were transferred to other specialized psychiatric or rehabilitation facilities.
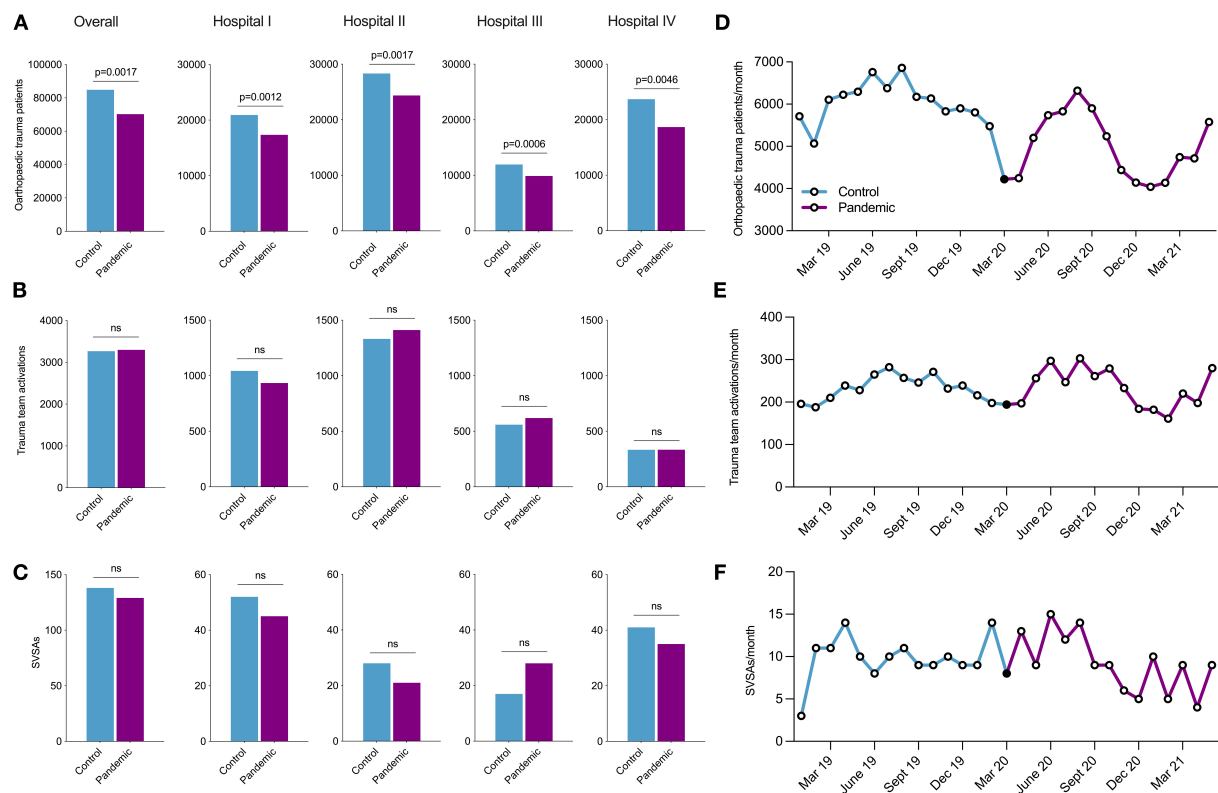
FIGURE 2
Overall and hospital-specific distribution of **(A)** orthopaedic trauma patients, **(B)** trauma team activations, and **(C)** SVSAs during the 14-month control (blue) and pandemic period (purple). Longitudinal distribution of **(D)** orthopaedic trauma patients, **(E)** trauma team activations, and **(F)** SVSAs per month during the control (blue) and pandemic period (purple). March 2020 (black dot) was excluded from the analyses. SVSAs, serious violent suicide attempts.

Overall, SVSA patients spent a median (IQR) of 11 (3;24) days in hospital during the control period and 6.5 (2;21) days during the pandemic period. This included a median (IQR) of five (2;12) and three (2;9) days in the ICU during respective periods (Figure 3D and Table 1).

Discussion

The present study demonstrates a constant rate of SVSAs and trauma team activations during a 14-month period during the COVID-19 pandemic compared to a preceding control period. Furthermore, we were able to show that the quality of SVSAs, including suicide method, injury severity, type of treatment, and admission time did not change between the two assessed periods. Yet, the total number of orthopaedic trauma patients decreased significantly, in the EDs of four Level-I Trauma Centers in Berlin, Germany.

While previous studies reported an increase in depression and suicidal ideation during the COVID-19 pandemic (28, 31, 33, 34), most high volume data on actual suicide attempts failed

to show a concomitant increase in suicides (10, 11, 32, 35–37). Our data are in line with these findings and we were able to show that violent suicide attempts did not increase during the first 14 months of the pandemic in Berlin, Germany. Nevertheless, few studies with limited patient numbers have demonstrated an increase in suicide rates during specific periods amid the COVID-19 pandemic in 2020 (12–15). Previous health crises, including the SARS epidemic in Hong Kong and the Ebola virus epidemic in Guinea led to an increase in suicide attempts and completed suicides (39), however, thus far this has not been the case for the COVID-19 pandemic.

While previous health crises, including the SARS epidemic in Hong Kong, and the Ebola virus epidemic in Guinea led to an increase in suicide attempts and completed suicides (38), thus far this has not been the case for the COVID-19 pandemic.

Reasons for this may have been prompt economical support programs, implemented in Germany, which helped to reduce financial losses for individuals and companies (39). While recessions have previously been linked to increased suicide rates, the effect seemed to be less pronounced in countries with larger social welfare spending (40–42).
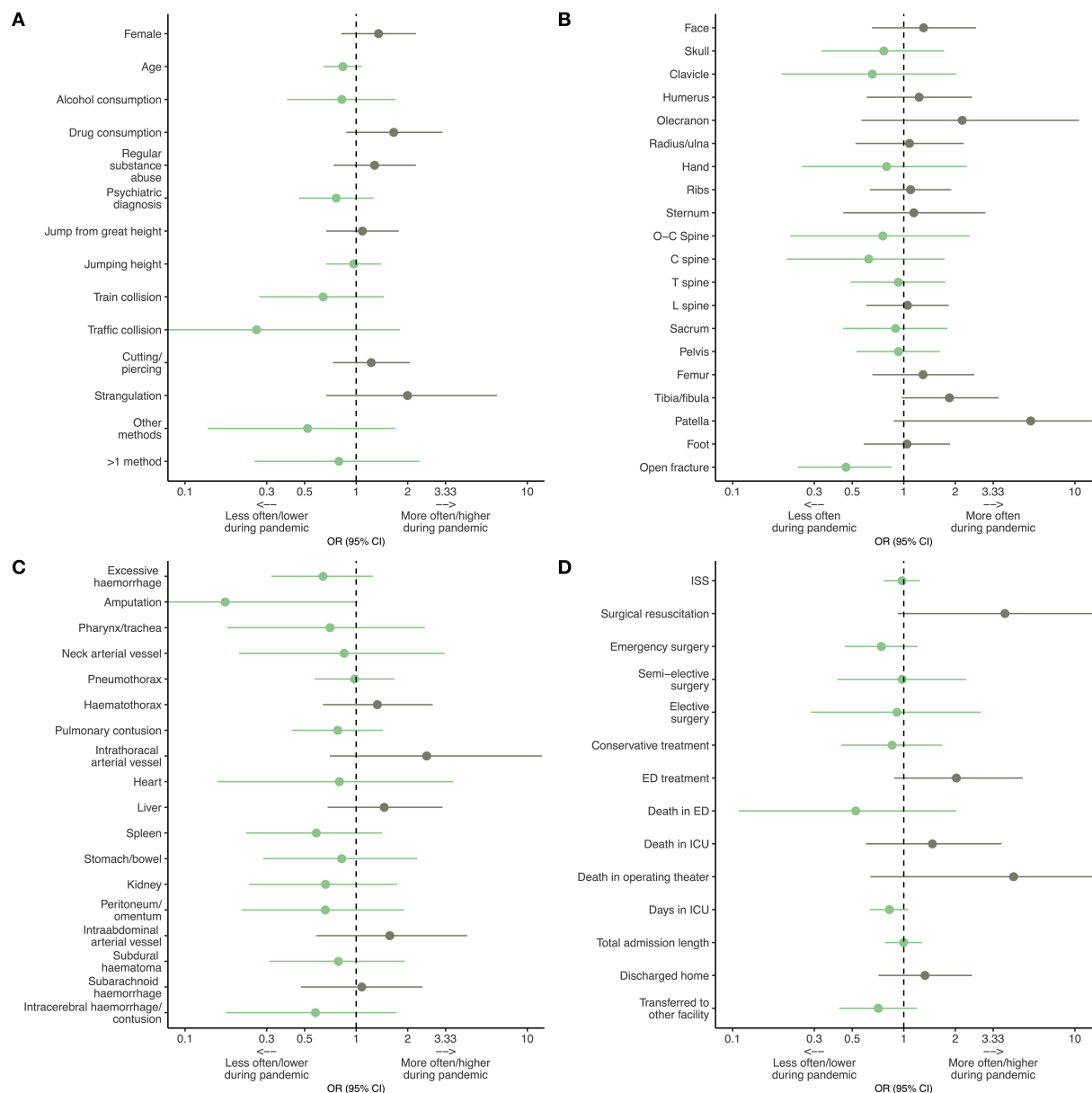
FIGURE 3
Odds ratios (ORs) for **(A)** demographics and suicide methods, **(B)** osseous injury patterns, **(C)** non-osseous injury patterns, **(D)** Injury Severity Score (ISS), treatment and outcomes of patients who undertook serious violent suicide attempts (SVSAs) during the COVID-19 pandemic and a proceeding control period. Green confidence intervals (95% CIs) indicate an event happening less often during the pandemic, whereas gray 95% CIs represent events happening more often during the pandemic. To obtain symmetric CIs, a log-scaled x-axis was used (few, very wide CIs were cut for proper display). ED, emergency department; C spine, cervical spine; ICU, intensive care unit, L spine, lumbar spine, O-C spine, occipito-cervical spine, T spine, thoracic spine.

Second, access to healthcare during the COVID-19 pandemic was perceived as reasonably good among the German population (43). Notably, access to healthcare has previously also been shown to be a crucial factor in suicide prevention (44, 45).

It is however too early to finalize conclusions on suicide rates during the COVID-19 pandemic, which is still ongoing in various countries worldwide. Although the majority of currently published studies on the topic could not show an increase in suicide attempts and completed suicides during the pandemic (10, 11, 32, 35–37), suicides may still rise with a certain delay, as previously seen in periods following natural catastrophes in the US (46).

In a Swedish registry-based study, cutting or piercing accounted for 35.6% of violent index suicide attempts and only for 4.8% of completed violent suicides (18). In line with these findings, we observed cutting or piercing in 29.7% of cases ($n =$ 41) during the control, and in 34.1% of cases ($n =$ 44) during the pandemic period.

While we saw jumps from great heights in 40.6% ($n = 56$) of the study population during the control and in 42.6% ($n = 55$) of cases during the pandemic period, they only accounted for 9.5% of violent index attempts and 8% of completed violent suicides in the Swedish registry-based study (18). This marked difference may be attributed to our study population, exclusively derived from an urban environment. It was previously described that the accessibility to lethal methods, including living in higher buildings, determines the method of suicide (47).

One study from South Korea reported a decline in violent suicide attempts ("self-harm injury") from 82.6% before the pandemic (January–October 2019) to 30% during the pandemic (January–October 2020), while they observed a rise in drug overdoses from 13.3 to 66.6% (14).

Marked differences can be observed between suicide completers, where hanging is the most prevalent method, and suicide attempters, where poisoning is most commonly observed (48). The method chosen at the index suicide attempt also predicts the chances of suicide completion at a later point. Suicide completers most commonly chose the same method during an index suicide attempt (90% for hanging) (49).

Effects of seasonality, weather, and temperature on suicide rates have been extensively reported in previous decades. While suicide peaks were described for spring and late summer in the 1960s—1980s (50, 51) more recent data indicate that seasonal patterns have diminished regarding suicide rates. Reasons identified are an increased intensity of communal life and technological developments (52–54). Accordingly, our data showed no differences in SVSA rates, when controlled for seasonality.

While incidences of neuro-psychiatric diagnoses rose during the COVID-19 pandemic, in both, patients suffering from COVID-19 (55) and healthy individuals (28), early reports also suspected a direct translation into suicide attempts (30, 56). In a commentary, Sher reported a high probability of patients suffering from post-COVID-19 syndrome to show an increase in suicidal ideation and behavior due to long-term psychiatric, neurological, and physical illness (57). To date, most data could not confirm concerns about increased suicide rates during the COVID-19 pandemic, raised in various editorials, reviews and commentaries.

Reporting on suicidal behavior must be conducted with caution, as misleading data and sensational media coverage may considerably influence suicide intentions and imitations. Scientific reporting is obligated to be conducted in a precise

and balanced manner and should focus on facts rather than speculations (29, 58).

This study has several limitations. We were able to analyze ED records of four Level-I Trauma Centers, yet, our data is merely representative for the urban area of Berlin, Germany. While conclusions could be relevant for other capital regions, they may fall short when looking at provincial areas or countries with alternate urban environments (47). Second, shutdown measures varied greatly between regions and countries. Therefore, data may be interpreted with caution and should always be put in perspective to available international evidence. Third, the retrospective character of our study does not allow assumptions about causation, but rather about associations between the COVID-19 pandemic and suicidal behavior. Finally, this study only covered the first 14 months of the COVID-19 pandemic and conclusions for the pandemic as a whole are not valid at this point. Most studies reporting on suicide numbers and rates have however covered shorter time periods and long-term data is still scarce.

To address a potential selection bias based on hospital location, we included four Level-I Trauma Centers that geographically form a string spanning from West to East Berlin. We thereby anticipated to minimize a geographical or socioeconomical selection of patients.

Retrospective chart review studies often include a relevant documentation bias (data entry, data collection, and data quality assurance). We employed a standardized data retrieval sheet (Microsoft Excel) for all four participating centers to ensure obtained data are of similar quality. Following the guide of Gearing et al. (26), sections for each variable in the data retrieval sheet were created using simple and unambiguous response options. Nonetheless, documentation of e.g., alcohol consumption or history of mental illness is highly dependent on the documenting physician and may be a relevant source of bias.

The COVID-19 pandemic may have just surpassed its peak and new virus variants, including Omicron, seem to cause milder symptoms in affected individuals compared to previous virus strains. Nonetheless, lockdown and shutdown measures are still in place in numerous countries to date. Recent data indicated that restrictions and subsequent self-isolation related to COVID-19 correlated with a rise in psychiatric diagnoses. Whether this would also impact suicide attempts was discussed by a number of authors.

This study was able to demonstrate that violent suicide attempts did not change in quantity nor in quality during the COVID-19 pandemic compared to a control period prior to the SARS-CoV-2 outbreak in 2019/2020. These data may help to map out "collateral damage" scenarios resulting from social distancing, while preparing for future pandemics. Whether current lockdown and shutdown measures have an impact on long-term mental health and suicidal behavior remains to be seen.

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 Ethikkommission der Charité – Universitätsmedizin Berlin. 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

TM and SM designed and conceived the study. TM, TT, ADD, ED, GR, MZ, RC, MK, PW, and FF provided, selected, assembled, analyzed, and interpreted data. DZ and LSH provided statistical, graphical and software support. TT, US, TF, DG, NS, AR, and SM curated data and provided project administration. TM drafted the original manuscript. All authors agree to be accountable for the work as a whole and ensure that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors critically reviewed and edited the final manuscript and have read and confirmed the final version, submitted to Frontiers in Psychiatry.

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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Trends in online searching toward suicide pre-, during, and post the first wave of COVID-19 outbreak in China

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COVID-19 may increase the risk of suicide, but the conclusion is still unclear. This study was designed to assess the impact of COVID-19 on suicide pre-, during, and post the first wave of COVID-19 in China. It was reported that online public searching was associated with their offline thoughts and behaviors. Therefore, this study was designed to explore the online search for suicide pre-, during, and post-COVID-19 in China. The keywords on suicide, COVID-19, unemployment, and depression were collected in 2019 and 2020 using the Baidu Search Index (BSI). A time-series analysis examined the dynamic correlations between BSI-COVID-19 and BSI-suicide. A generalized estimating equation model was used to calculate the coefficients of variables associated with the BSI-suicide. The BSI-suicide showed a significant increase (15.6%, $p = 0.006$) from the 5th to 9th week, which was also the point of the first wave of the COVID-19 outbreak. A time-series analysis between BSI-suicide and BSI-COVID-19 showed that the strongest correlation occurred at lag 1+ and lag 2+ week. In the pre-COVID-19 model, only BSI-depression was highly associated with BSI-suicide ($\beta = 1.38$, $p = 0.008$). During the COVID-19 model, BSI-depression ($\beta = 1.77$, $p = 0.040$) and BSI-COVID-19 ($\beta = 0.03$, $p < 0.001$) were significantly associated with BSI-suicide. In the post-COVID-19 model, BSI depression ($\beta = 1.55$, $p = 0.010$) was still highly associated with BSI-suicide. Meanwhile, BSI-unemployment ($\beta = 1.67$, $p = 0.007$) appeared to be linked to BSI-suicide for the first time. There was a surge in suicide-related online searching during the early stage of the first wave of the COVID-19 outbreak. Online suicide search volume peaked 1–2 weeks after the COVID-19 peak. The BSI of factors associated with suicide varied at different stages of the COVID-19 pandemic. The findings in this study are preliminary and further research is needed to arrive at evidence of causality.

KEYWORDS

COVID-19, suicide, online searching behavior, depression, social psychiatry

Introduction

COVID-19 has swept the world swiftly since being diagnosed and is still in its rage. COVID-19 has brought great disasters to humanity and would change the lifestyle of human beings in the short and long term, even if it can be controlled soon. Those changes will disturb our everyday life, work, and learning and pose tremendous pressure on all kinds of walks. Furthermore, it was reported that COVID-19 would significantly increase the risk of suicide in previous studies (1–3). Several factors underpinned these concerns, including a deterioration in population mental health, a higher prevalence of reported thoughts and behaviors of self-harm among people with COVID-19, problems accessing mental health services, and evidence suggesting that previous epidemics, such as severe acute respiratory syndrome (SARS), were associated with a rise in deaths by suicide (2, 4, 5). Widely reported studies modeling the effect of the covid-19 pandemic on suicide rates predicted increases ranging from 1 to 145%, mainly reflecting variation in underlying assumptions (6). Supposition is no replacement for evidence, and timely data on rates of suicide are vital. Several studies reporting suicide trends have emerged more recently. Overall, the literature on the effect of COVID-19 on suicide should be interpreted with caution (6). Nevertheless, a reasonably consistent picture is beginning to emerge from high-income countries. Some studies reported that the suicide rate did not increase at the early stages of the pandemic (7, 8) but most reported an increase in the suicide rate during the epidemic (2, 9, 10). The picture is much less evident in the middle- and low-income countries, where the safety nets available in better-resourced settings may be lacking. China should be the first country in the world to witness the entire process of pandemic control. Unfortunately, longitudinal epidemiological data on suicide have not been available in China. With the ubiquitous availability of the Internet, the collection and analysis of online searching behavior information have become a necessary supplement to predict the trends of "offline" behavior on suicide. Previous studies verified that *online* searching behaviors of the public were associated with their offline thoughts and behaviors (11–14). In this study, we tried to understand the suicide behaviors by analyzing their online search behaviors pre-, during, and post-COVID-19 pandemic in China.

Materials and methods

The daily online search volume of suicide-related keywords during the first wave of COVID-19 from 1 January to 31 December 2020 was collected using the Baidu Search. As the most crucial searching tool in China, Baidu Search offers Baidu Index Service (BIS)[1], as well as Google Trends, allowing the registered users to harness data on searched keywords. According to the 2021 Chinese search engine user behavior study report released by China Internet Network Information Center Reports, as of June 2021, China's Internet users have reached *1.011 billion.* The number of search engine users has reached *795 million*, with the user penetration rate of Baidu search exceeding *90%*. The Baidu Search Index (BSI) was one of the functions of BIS, which was calculated by weighting the search frequency of each keyword in Baidu search according to the search volume of internet users and the keywords. The BSI of suicide-related terms was collected to comprehensively explore the factors associated with online searching behaviors, such as COVID-19, depression, and work status.

The detailed retrieval processes were as follows (keywords in Chinese, as shown in **Supplementary Table 1**): terms being used for searching would include: a combination of "COVID-19' and "New Coronavirus" for COVID-19; "Suicide" and "Want to die" for suicide; "Depressed" for depression; "Unemployment" for working status. The search terms were matched by searching the keywords database of the Baidu Index Service according to searched contents. In addition, the selection of keywords referred to the demand graph analysis of searching keywords offered by the Baidu index. The demand graph analysis can show the demand for searched words shown by the changes in users' searching behavior before and after the keyword search and can help in defining the exact keyword. The search content was determined with reference to the main socio-economic and psychosocial factors associated with suicide reported in previous studies. The retrieved areas covered the whole country. Furthermore, to further explore the impact of the COVID-19 pandemic on suicide-related keywords searching, the volumes of these keywords searched in the same period of 2019 were also collected. As a result, according to the epidemic of COVID-19 in China, the whole year of 2019 and the 1st–3rd week from the beginning of 2020 were defined as Pre-COVID-19; the timespan from lockdown to the reopening of Wuhan was defined as the time during the COVID-19 pandemic (from the 4th to 15th week of 2020); and the timespan from the reopening of Wuhan to the end of 2020 was defined as Post-COVID-19.

Data analysis and statistics

The mean/median BSI was used to describe the average searching volume of those keywords for each week. A cross-correlogram for bivariate time series was employed further to demonstrate the dynamic correlations between BSI-COVID-19 and BSI-suicide contemporaneously and at various lagged values from the 1st to 53rd week in 2020. Granger Causality

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1   https://index.baidu.com/v2/index.html#/

assumptions (15) have been verified and employed to verify the causal relationship between BSI-COVID-19 and BSI-suicide after the cross-correlation analysis. To identify changes in searching trends, joinpoint regression was estimated for every keyword using the Joinpoint Regression Program, Version 4.9.0.0. The Joinpoint Regression Program is a trend analysis software developed by the U.S. National Cancer Institute to analyze data from the Surveillance Epidemiology and End Results Program (16). The joinpoint regression model is designed to describe continuous changes and uses the grid-search method to fit the regression function with unknown joinpoints assuming constant variance and uncorrelated errors. The number of significant joinpoints was identified by performing several permutation tests, each of which has a correct significance level asymptotically. Each p-value is found using Monte Carlo methods, and the overall asymptotic significance level is maintained through a Bonferroni correction. The Joinpoint Regression Program performs a series of hypothesis tests that test the null hypothesis of k_a joinpoints against the alternative hypothesis of k_b joinpoints, where k_a and k_b change for each hypothesis test. Each p-value corresponds to this type of test. The p-value is an estimate of the probability, under the assumption that there are only k_a joinpoints, of observing data that look more like a joinpoint model with greater than k_a joinpoints than the data we have observed. This method describes changes in data trends by connecting several line segments on a log scale at "joinpoints."

In addition, a weekly percent change (WPC) in BSIs for each line segment and the corresponding 95% confidence interval (*CI*) were estimated. Finally, the WPC is tested to determine whether a difference exists from the null hypothesis of no change (0%). In the final model, each joinpoint informs a statistically significant change in trends (increase or decrease), and each of those trends is described by a WPC. The Generalized Estimating Equation (GEE) model was used to estimate the coefficient (95% *CI*) of variables associated with the BSI-suicide between 2019 and 2020. The database was constructed with EpiData v. 3.1 (EpiData Association, Denmark), and data were analyzed using SPSS v. (SPSS, Inc., Chicago, IL, United States).

Results

Baidu Search Index for suicide between 2019 and 2020

Considering the development and control of the COVID-19 pandemic in China, this study described and compared BSIs weekly. There were 53 weeks, and BSI for suicide ranged from 3,692 to 7,109 in 2020 and 5,051 to 9,788 in 2019. Compared with the same period in 2019, the BSI-suicide increased sharply from the 5th to 9th week in 2020, with the year-on-year growth rate soaring from −54

to 5.4%. It fluctuated from the 10th week and decreased gradually in the following weeks. However, it began to pick up slightly from the 46th week to the end of the year (as shown in **Figure 1**). The month-over-month fluctuations in 2020 were also up and down, especially at the year's beginning and end.

Trends in Baidu Search Index-suicide and related factors between 2019 and 2020 according to the joinpoints identified by the analysis

Table 1 presents the WPC of BSI-suicide and related factors in China between 2019 and 2020. The BSI-suicide significantly decreased from the 1st to 5th week (−7.5%, $p = 0.016$), increased from the 5th to 9th week (15.6%, *$p = 0.006$*), and dropped from the 9th to 45th week (−0.9%, *$p < 0.001$*) in 2020. However, the whole year of 2019 showed a slow downward trend (−0.2%, *$p = 0.044$*). The BSI-depression significantly decreased from the 1st to 4th week (−8.3%, *$p = 0.015$*), increased from the 4th to 11th week (8.8%, *$p < 0.001$*), and slightly decreased from the 11th to 25th week (−0.9%, *$p = 0.012$*) and from the 28th to 51st week (−2.26%, *$p < 0.001$*) in 2020. The trend for the BSI-depression in 2019 showed a fluctuating state with an extensive range. Both BSIs for unemployment significantly decreased from the 1st to 4th week, both in 2019 (−15.3%, *$p = 0.023$*) and 2020 (−19.7%, *$p = 0.002$*) but increased significantly from the 4th to 15th week (16.0%, *$p < 0.001$*) and slightly decreased from the 15th to 30th week (−5.3%, *$p < 0.001$*) in 2020. Consistent with the development of COVID-19, the BSI-COVID-19 increased significantly from the 1st to 6th week (1,243.4%, *$p < 0.001$*), followed by a slightly decreased trend from the 6th to 53rd week (−1.5%, $p = 0.05$).

Cross-correlation and causal relationship between Baidu Search Index-suicide and Baidu Search Index-COVID-19

A time-series analysis on the dynamic correlations between BSI-suicide and BSI-COVID-19 showed that the strongest correlation occurred at lag 1+ and 2+ (as shown in **Figure 2** and **Supplementary Figure 1**), suggesting that the peak BSI-COVID-19 can lead to peak BSI-suicide 1 or 2 weeks later. In addition, the cross-correlations from lags +3 to lags +7, lags −1 to −4, and lags −11 to −18 showed different degrees of the positive correlation between BSI-COVID-19 and BSI-suicide. However, the cross-correlations from lags +7 to +19 and lags −20 to lags −23 suggested that the BSI-COVID-19 and BSI-suicide were negatively related over time. Varsoc

FIGURE 1

Time trends for the weekly Baidu Search Index (BSI)-suicide in 2019 and 2020.
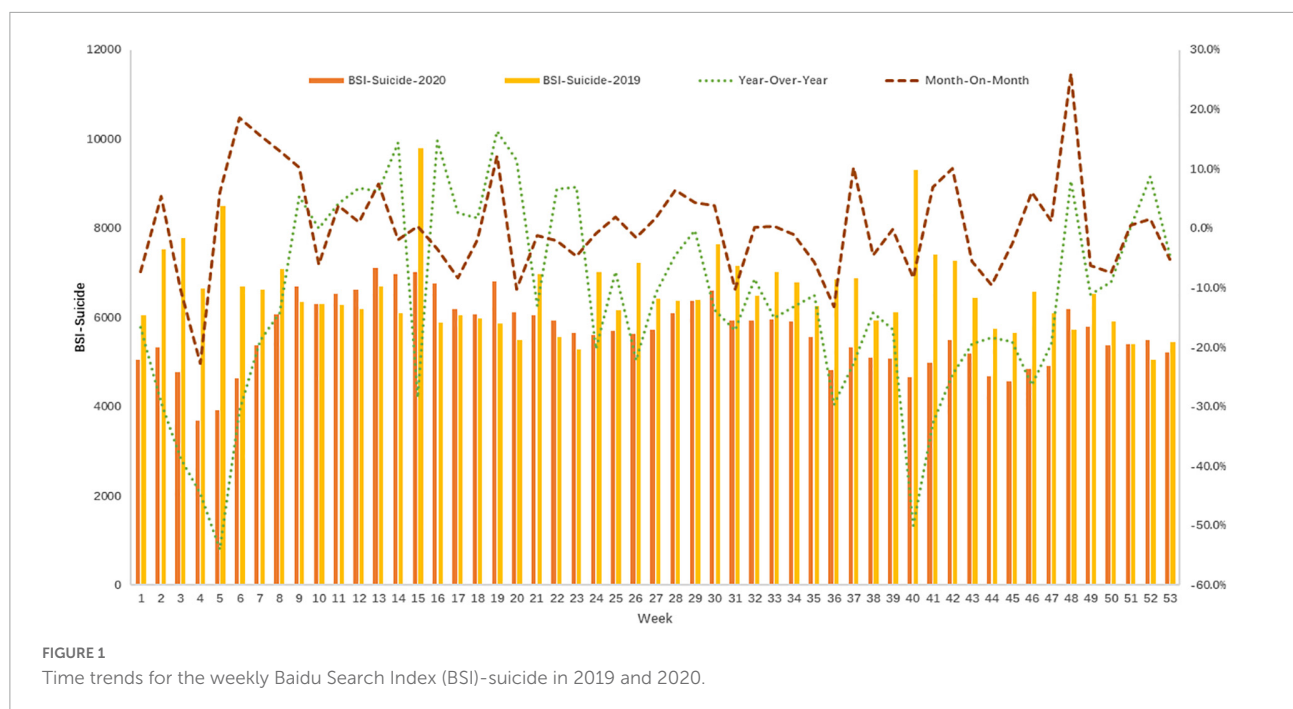
TABLE 1 Trends in Baidu Search Index (BSI)-suicide and associated factors from 1st to 53rd week both in 2019 and 2020[†].

	Segments	2019				2020			
		Week	WPC[a]	95%CI		Week	WPC	95%CI	
				Lower	Upper			Lower	Upper
Suicide	Trend 1	1–53	−0.2*	−0.5	−0.0	1–5	−7.5*	−13.2	−1.5
	Trend 2	–	–	–	–	5–9	15.6**	4.6	27.7
	Trend 3	–	–	–	–	9–45	−0.9***	−1.2	−0.7
	Trend 4	–	–	–	–	45–53	1.6	−0.6	3.9
Depression	Trend 1	1–17	3.0***	2.2	3.9	1–4	−8.3*	−14.4	−1.8
	Trend 2	17–30	−2.6***	−3.8	−1.5	4–11	8.8***	6.3	11.3
	Trend 3	30–33	13.2	−7.9	39.0	11–25	−0.9*	−1.7	−0.2
	Trend 4	33–38	−5.7	−11.7	0.6	25–28	6.5	−7.1	22.3
	Trend 5	38–41	18.7	−3.4	45.8	28–51	−2.3***	−2.6	−1.9
	Trend 6	41–53	−5.0***	−6.2	−3.8	51–53	8.6	−5.4	24.6
COVID-19	Trend 1	–	–	–	–	1–6	1,243.4***	751.8	2,018.8
	Trend 2	–	–	–	–	6–53	−1.5*	−3.1	0.0
Unemployment	Trend 1	1–4	−15.3*	−26.5	−2.4	1–4	−19.7**	−29.9	−8.0
	Trend 2	4–7	17.4	−11.6	55.8	4–15	16.0***	13.6	18.5
	Trend 3	7–53	−0.4**	−0.6	−0.1	15–30	−5.3***	−6.5	−4.1
	Trend 4	–	–	–	–	30–53	0.2	−0.4	0.9

[a]WPC, weekly percentage change; 95%CI, 95% confidence interval; *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. [†]Segment data can meet the assumptions of the log-linear model.

was used to estimate the optional lags and found that all likelihood, final prediction error (FPE), Akaike information criterion (AIK), Hannan–Quinn information criterion (HQIC), and Schwarz–Bayesian information criterion (SBIC) had chosen a model with one lag. Granger causality Wald tests showed

that the lagged values of BSI-COVID19 caused BSI-suicide ($\chi^2 = 8.192$, $p = 0.004$) and lagged values of BSI-suicide did not cause BSI-COVID-19 ($\chi^2 = 8.192$, $p = 0.004$). The direction of causality is from BSI-COVID-19 to BSI-suicide.

FIGURE 2
A cross-correlation function for the weekly BSI-COVID-19 and BSI-suicide in 2020.

Factors associated with Baidu Search Index-suicide pre-, during, and post COVID-19

To explore potential factors associated with BSI-suicide, overall and subgroup GEE analyses stratified by the control of the COVID-19 pandemic were performed. The findings of the overall GEE analysis showed that BSI-depression was associated with BSI-suicide (regression coefficient, β = 0.99, p = 0.001, **Table 2**) under the condition that BSI-suicide significantly decreased over 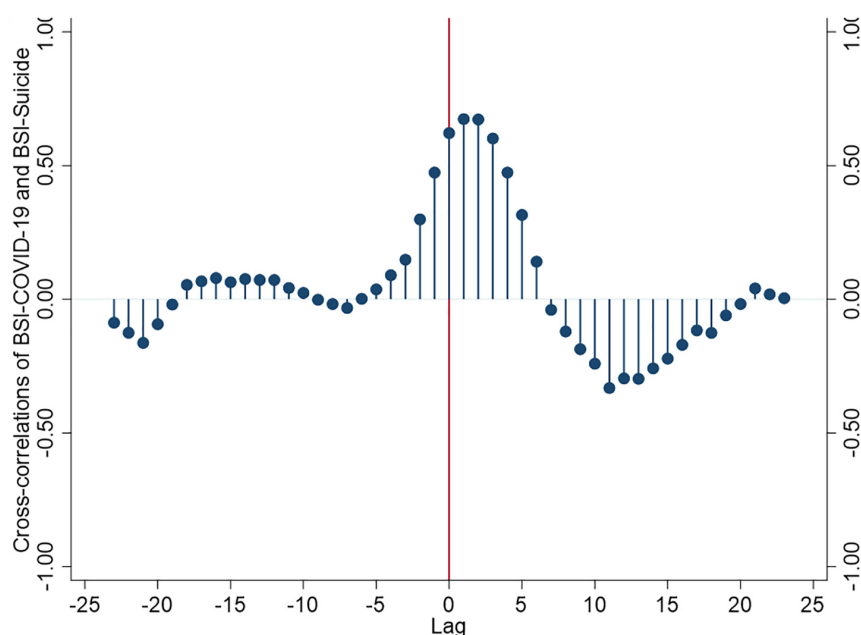time (regression coefficient, β = −13.87, p = 0.003). In the pre-COVID-19 model, only BSI-depression was positively associated with BSI-suicide over time (regression coefficient, β = 1.38, p = 0.008). During the COVID-19 model, BSI-depression (regression coefficient, β = 1.77, p = 0.040) and BSI-COVID-19 (regression coefficient, β = 0.03, p < 0.001) showed a highly significant association with BSI-suicide. In the post-COVID-19 model, BSI-depression (regression coefficient, β = 1.55, p P = 0.010) was still highly associated with BSI-suicide. Meanwhile, BSI-unemployment (regression coefficient, β = 1.67, p = 0.007) was linked to BSI-suicide for the first time.

Discussion

This study was the first to explore the impact of the first wave of the COVID-19 outbreak on suicide through longitudinal online searching data in China. Previous studies had reported that online public searching could be a potential predictor for their offline thoughts and behaviors ([11], [13]). With the deep integration of Internet use behavior into daily life, people tend to retrieve information and help from the Internet, especially in the face of sudden public health time, such as COVID-19. Therefore, network behavior analysis can be used as a supplementary monitoring means of suicidal behavior during the epidemic.

The study found a surge in BSI-suicide during the early COVID-19 outbreak and the peak searching volume for COVID-19, especially from the 5th to 9th week. Since the 10the week, BSI-suicide began to show a downward trend, also a turning point for China's COVID-19 control. A national online cross-sectional survey performed between 28 February and 11 March 2020, reported that the prevalence of suicidal ideation in China during the COVID-19 outbreak was as high as 16.4% ([17]). Another online survey involving 1,172 participants found that the high risk of suicide and behavior prevalence was 2.8% ([18]). A meta-analysis study suggested that increased event rates for suicide ideation were 10.81%, suicide attempts 4.68%, and self-harm 9.63%, respectively, during the COVID-19 pandemic ([2]). An exciting finding was the lag effect that the peak of BSI-suicide was 1–2 weeks later than the peak of BSI-COVID-19. The above discovery might be related to understanding the COVID-19 pandemic for the public. In the early stage of the COVID-19 pandemic, more attention was paid to the disease's infectivity and severity. After a preliminary understanding of the risk, the search for emotional problems, such as panic, stress, and depression, would occur in a short period, which would lead to an increase in the search for suicide. This process

TABLE 2   Associations between Baidu Search Index (BSI)-COVID-19 and BSI-suicide pre-, during, and post-COVID-19 pandemic in China*.

Variables	Overall		Stratified by COVID-19 epidemic					
			Pre-COVID-19		During COVID-19 pandemic		Post-COVID-19	
	β (95%CI)	P	β (95%CI)	P	β (95%CI)	P	β (95%CI)	P
BSI-depression	0.99 (0.40–1.58)	0.001	1.38 (0.36–2.41)	0.008	1.77 (0.08–3.46)	0.040	1.55 (0.37–2.72)	0.010
BSI-unemployment	0.96 (−0.07 to 2.00)	0.067	−1.43 (−6.40 to 3.54)	0.574	0.49 (−0.78 to 1.76)	0.446	1.67 (0.46–2.88)	0.007
Time (week)	−13.87 (−23.00 to −4.74)	0.003	−16.42 (−33.54 to 0.70)	0.060	27.03 (−197.59 to 251.64)	0.814	4.88 (−25.77 to 35.53)	0.755
BSI-COVID-19	0.01 (0.00–0.03)	0.097	–	–	0.03 (0.02–0.04)	<0.001	−0.01 (−0.03 to 0.01)	0.259

*GEE model (family = gaussian; link = identity; corr = exchangeable).

took about 1–2 weeks, indicating the critical time window for suicide prevention. Previous studies have reported that mental health consequences of the COVID-19 crisis, including suicidal behavior, are likely to peak later than the actual pandemic (3, 19).

Consistent with the fact that depression makes substantial contributions to suicide across the lifespan (20–22), online search behavior obtained the same conclusion that BSI-depression was strongly associated with BSI-suicide at any stage of the COVID-19 epidemic. This finding also confirmed that the online search behavior could effectively reflect netizens' offline thoughts and behaviors.

In addition, the regression coefficient also indicated that the association between BSI-depression and BSI-suicide was strengthened during the COVID-19 pandemic, suggesting that coping with depression problems should be sustained and strengthened. Furthermore, the subgroup analysis showed that BSI-COVID-19 contributed to BSI-suicide only during the COVID-19 outbreak period, which might be related to the effective control of the pandemic in China soon after the outbreak. Finally, it is worth noting that BSI unemployment was associated with BSI-suicide and BSI-depression in the post-COVID-19 period. As for the relationship between depression and suicide, previous studies have reported the association between unemployment and suicide during or not during the COVID-19 pandemic (7, 17, 22, 23). These findings suggest that in the post-COVID-19 era, the focus of suicide prevention needs to be expanded or adjusted from COVID-19-induced mental problems to a comprehensive scope, such as unemployment in this study (23). Those changes should be recognized and valued. Notably, in this study, the correlations between keyword searching behavior to suicide and other related factors were consistent with the results of population questionnaires in previous studies (3, 24). It also confirms the possibility of mutual predictability between online retrieval behavior and offline behavior. Previous studies have reported that mass media have played a critical role in spreading the COVID-19 and addressing netizens' online searching interest (25–27), thus favoring the increasing searching for COVID-19. Meanwhile, it can also spread panic and fear among the public, increasing the online searching for psychological

symptoms, such as suicide-related words. Moreover, searching for depression and unemployment was also affected by mass media. Therefore, it is noted that the online search relationship between suicide-related keywords and other keywords might be strengthened by related mass media report. This study, based on a 2-year longitudinal keyword online searching of more than *700 million* netizens, explored the impact of COVID-19 on suicide and factors associated with BSI-suicide over time. However, this study had several limitations. First, this study only analyzed the effects of COVID-19 on suicide through online searching behaviors, which could not replace the online or offline questionnaire investigation. Still, it can provide valuable references and supplement for understanding of the impact of COVID-19 on suicide. In addition, participants only included netizens, but not those who never surf the Internet or those who surf the Internet but without searching behaviors, even though they were in the minority. Second, due to the availability of the search keywords in the database, only a few representative factors related to suicide were analyzed. Third, factors associated with suicide search behaviors might differ across countries and over time, depending on conditions, such as the control of the epidemic, the capacity of existing mental health services, and suicide prevention programs, making the extrapolation of the results cautious. Finally, the seasonal factor might affect the online search amount during the study period.

Conclusion

Under the condition that the COVID-19 pandemic was brought under control quickly, peak BSI-suicide occurred 1–2 weeks later than the pandemic outbreak and gradually decreased over time. BSI-depression had always contributed to BSI-suicide regardless of COVID-19, but this contribution had increased during the outbreak phase. In the post-COVID-19 era, further attention should be paid to other factors associated with BSI-suicide, such as BSI-unemployment, which might be related to the later effect of the epidemic on the economy.

In addition, online searching of keywords related to suicide varied at different stages of the COVID-19 pandemic. The findings in this study are preliminary and further research is needed to arrive at evidence of causality. Nevertheless, these findings provide another profile of suicide among netizens pre-, during, and post-COVID-19 epidemic and underscore the significance of policy-making and suicide prevention in public health emergencies. These findings suggest that in the post-COVID-19 era, the focus of suicide prevention needs to be expanded or adjusted from COVID-19-induced mental problems to a comprehensive scope, such as unemployment in this study. Those changes should be recognized and valued.

Data availability statement

The raw data supporting the conclusions of this article will be made available upon reasonable request to the corresponding author.

Author contributions

HC and SL: concept and design, had full access to all the data in the study, takes responsibility for the integrity of the data, and the accuracy of the data analysis. HC and HL: acquisition, analysis, or interpretation of data. HC and KZ: drafting of the manuscript. HC: statistical analysis. SL: obtained funding. KZ and ML: administrative, technical, or material support. ML and HC: supervision. All authors critically revised the manuscript for important intellectual content, 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/fpsyt.2022.947765/full#supplementary-material

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Impulsiveness indirectly affects suicidal ideation through depression and simultaneously moderates the indirect effect: A moderated mediation path model

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Objective: This study aims to investigate the indirect effect of impulsiveness on suicidal ideation through depression and the moderating effect of impulsiveness on the indirect effect in an integrated path model.

Methods: Self-rating depression scale (SDS), Barratt impulsiveness scale-11th version (BIS-11), and self-rating idea of suicide scale (SIOSS) were applied. A moderated mediation path model was established including impulsiveness, depression, and suicidal ideation as observed variables.

Results: The main results revealed that the moderated mediation path model fit well in describing the relationships among impulsiveness, depression, and suicidal ideation. The indirect effect of impulsiveness mediated by depression and the moderating effect of impulsiveness on suicidal ideation was significant. Multiple comparisons showed that the indirect effects under different conditions of impulsiveness had statistical differences. The higher the impulsiveness was, the stronger the predictive effect of depression on suicidal ideation was.

Conclusions: The present study confirms that people who have impulsive traits are riskier to generate suicidal thoughts because they are more likely to suffer from depression and that people who are depressive have even higher risk to develop suicidal thoughts when they simultaneously have impulsive traits. In clinical and health care work, when considering depression to prevent suicidal ideation, impulsiveness needs to be monitored throughout the process of premorbid and onset stages of depression.

Introduction

According to the newest worldwide statistics (1), about 9.2 persons per 100,000 died from suicide in 2019. Suicide is divided into three phases: suicidal ideation, suicide attempts and lethal suicide behavior (2). The prevalence rate of suicidal ideation, which ranges from 2.6 to 25.4% (3), is much higher than suicide attempts and lethal suicide behavior. It is thought to be an indispensable cognitive process before suicide actions take place (4, 5). Solano et al. found that the Internet searching behaviors of suicide-related information were positively correlated with the growth of suicide rates in the following three months (6). The Internet searching behaviors represent the existence of suicidal ideation (6). Therefore, Solano's study indicates that suicidal ideation is a preexisting factor of lethal suicide behavior. A large sample survey revealed that individuals with suicidal ideation were over four times more likely to commit suicide than whom without suicidal ideation (7). Accordingly, for suicide prevention, it is critical to detect, manage, and intervene in suicidal ideation.

As described in the diathesis-stress-model (8), vulnerable trait factors (diathesis) and unexpected life events [including subsequent negative/positive emotion and psychopaths, et al., namely, stress (9)] cause the onset of suicide behavior, specifically, suicidal ideation. Among the diathesis and stress, impulsiveness and depression have been widely studied, which are the two vital factors that confer high risk. However, it is inconsistent about how the two factors work together in suicidal cognitive process.

In some studies, impulsiveness and depression are two independent variables related to suicidal ideation (10–12). Another study constructed a linear regression model (13), finding that depression independently predicted suicidal ideation and that impulsiveness affected suicidal ideation through interacting with traumatic experience. It is inconsistent about whether impulsiveness can independently lead to suicidal ideation and not clear whether impulsiveness can interact with depression in predicting suicidal ideation.

The integrated motivational-volitional model holds that impulsiveness is an interacting variable with suicidal ideation in predicting suicide behavior, while does not mention the effect of impulsiveness on suicidal ideation nor its interaction with

any psychopaths (5). One study showed that, when depression existed, impulsiveness could raise the risk of suicide behavior rather than suicidal ideation (14). It indicates that impulsiveness interacts with depression in the onset of suicide behavior but not suicidal ideation. However, according to Beck's cognitive model of suicide (4), vulnerability and psychiatric disturbance jointly contribute to suicide related thoughts at first, and then lead to suicide behavior. This is possibly because not every "impulsiveness" in previous studies is a kind of diathesis. Some of them may refer to a kind of state (15). It may confuse the medical or public health personnel in considering whether to deal with impulsiveness as a diathesis to monitor or as a state to intervene.

State impulsiveness is a process of fast decision or behavior without thinking (16). However, trait impulsiveness is a stable style of behavior as a personality (17). It is subjectively measured by questionnaires, usually based on Barratt's impulsiveness model (18) or UPPS (urgency-premeditation-perseverance-sensation-seeking) impulsiveness model (19). State impulsiveness is less likely to take effect together with depression among the cognitive process of suicide (5). Therefore, in the present study, we mainly paid attention to trait impulsiveness (called "impulsiveness" in the following text). According to the integrated motivational-volitional model, we hypothesize that (trait) impulsiveness interacts with depression in predicting suicidal ideation, which can be described by a simple moderation model with the moderating effect of impulsiveness on the path from depression to suicidal ideation. However, the simple moderation model does not consider the correlation between impulsiveness and depression which have been proved closely correlated in previous studies (20–25). Therefore, according to Beck's cognitive model (4), in which vulnerability influences suicidal cognitive process through psychiatric disturbance, we hypothesize that impulsiveness indirectly affects suicidal ideation through depression.

Combining these two hypotheses, we construct a moderated mediation path model (MODMEDPM). The whole hypothesis of this study is that impulsiveness indirectly affects suicidal ideation through depression and simultaneously moderates the indirect effect. To be more reliable, we take the simple moderation path model (SMODPM) as the alternative model for comparison. The conceptual diagrams of MODMEDPM and SMODPM are shown in Figure 1.

Materials and methods

Participants

We applied cluster sampling method to select a cohort who was healthy in mentality. To control the confounding effects, we only recruited two grades of students, including 196

FIGURE 1
Conceptual diagrams of MODMEDPM **(A)** and SMODPM **(B)**. MODMEDPM—moderated mediation path model; SMODPM—simple moderation path model.
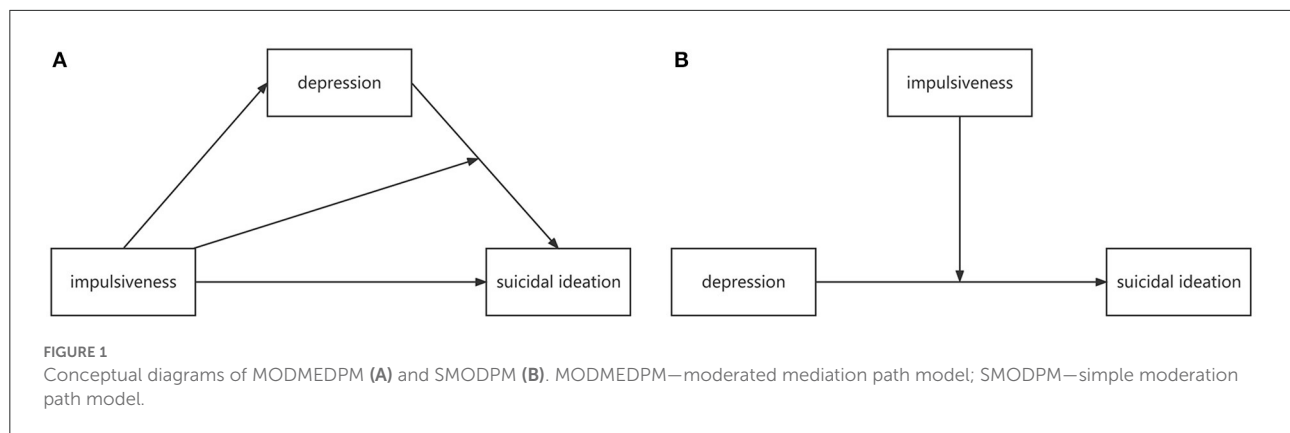
TABLE 1 Demographic characteristics and descriptive statistics.

Variables (group, score)	Total sample ($n = 480$)	
	n (%)	Mean (SD)
Gender (male, 1)	235 (49.0)	
Gender (female, 0)	245 (51.0)	
Grade (freshman, 1)	196 (40.8)	
Grade (sophomore, 0)	284 (59.2)	
Residence (urban, 1)	387 (80.6)	
Residence (rural, 0)	93 (19.4)	
Only child (1)	273 (56.9)	
Non-only child (0)	207 (43.1)	
Family structure (joint family, 1)	146 (30.4)	
Family structure (nuclear family, 2)	298 (62.1)	
Family structure (broken family, 3)	34 (7.1)	
Family structure (didn't report, null)	2 (0.4)	
Age	480 (100)	18.66 (0.80)
Impulsiveness-raw	480 (100)	72.50 (14.94)
Depression-raw	480 (100)	37.10 (9.06)
Suicidal ideation-raw	480 (100)	5.11 (4.00)
Impulsiveness-centered	480 (100)	0.00 (14.94)
Depression-centered	480 (100)	0.00 (9.06)
Suicidal ideation-centered	480 (100)	0.00 (4.00)

SD, standard deviation; "-raw", the raw scores; "-centered", the centered scores.

freshman (40.8%) and 284 sophomore (59.2%). Because the junior, senior and interns studied in different hospitals, who were faced with mixed stressors which could be confounding variables. The psychological tests were conducted within one month. All the 480 participants were examined. The cohort included 245 females (51.0%) and 235 males (49.0%) aged 16–21 (18.66 ± 0.80). Other demographic characteristics, including grade, residence, only child status, and family structure, as well as descriptive statistics of variables were shown in Table 1. There were two participants who did not report family structure. They

were rejected only when the family structure was included as a factor in the analysis.

Measures

Suicidal ideation

Suicidal ideation was assessed by the twenty-six-item Self-rating idea of suicide scale (SIOSS). This scale was developed in Chinese by Xia (26). The participants choose yes or no concerning whether they have symptoms or ideas described in the items. Higher sum scores imply stronger suicidal ideation. The SIOSS has good reliability and validity in the Chinese population (27–29). In the present study, this scale had acceptable reliability of internal consistency (Cronbach's alpha = 0.822).

Impulsiveness

The Barratt impulsiveness scale (SIOSS) consists of 30 items. It was originally developed by Ernest S. Barratt in 1959 (18). The 11th Chinese version of the BIS was revised under the context of Chinese culture and retained good reliability and validity (30). The BIS had fine internal consistency reliability (Cronbach's alpha = 0.909) in this study.

Depression

The Self-rating depression scale (SDS) was initially developed by William W. K. Zung in 1965 for evaluating depression in patients with depressive disorder (31). The scale consists of 20 items. It can also be used for preliminary screening in outpatient clinics (32), early detection of depression (33) or depressive state evaluation in the general population (34, 35). The Chinese version of the SDS has demonstrated good reliability and validity across various groups of people (36). Its internal consistency reliability was good (Cronbach's alpha = 0.879) in this study.

FIGURE 2
Statistical diagrams of baseline model **(A)**, MODMEDPM **(B)**, and SMODPM **(C)**. MODMEDPM—moderated mediation path model;
SMODPM—simple moderation path model; "impulsiveness × depression"—the interaction term; "e", "e1" and "e2"—the residual variances of
dependent variables.
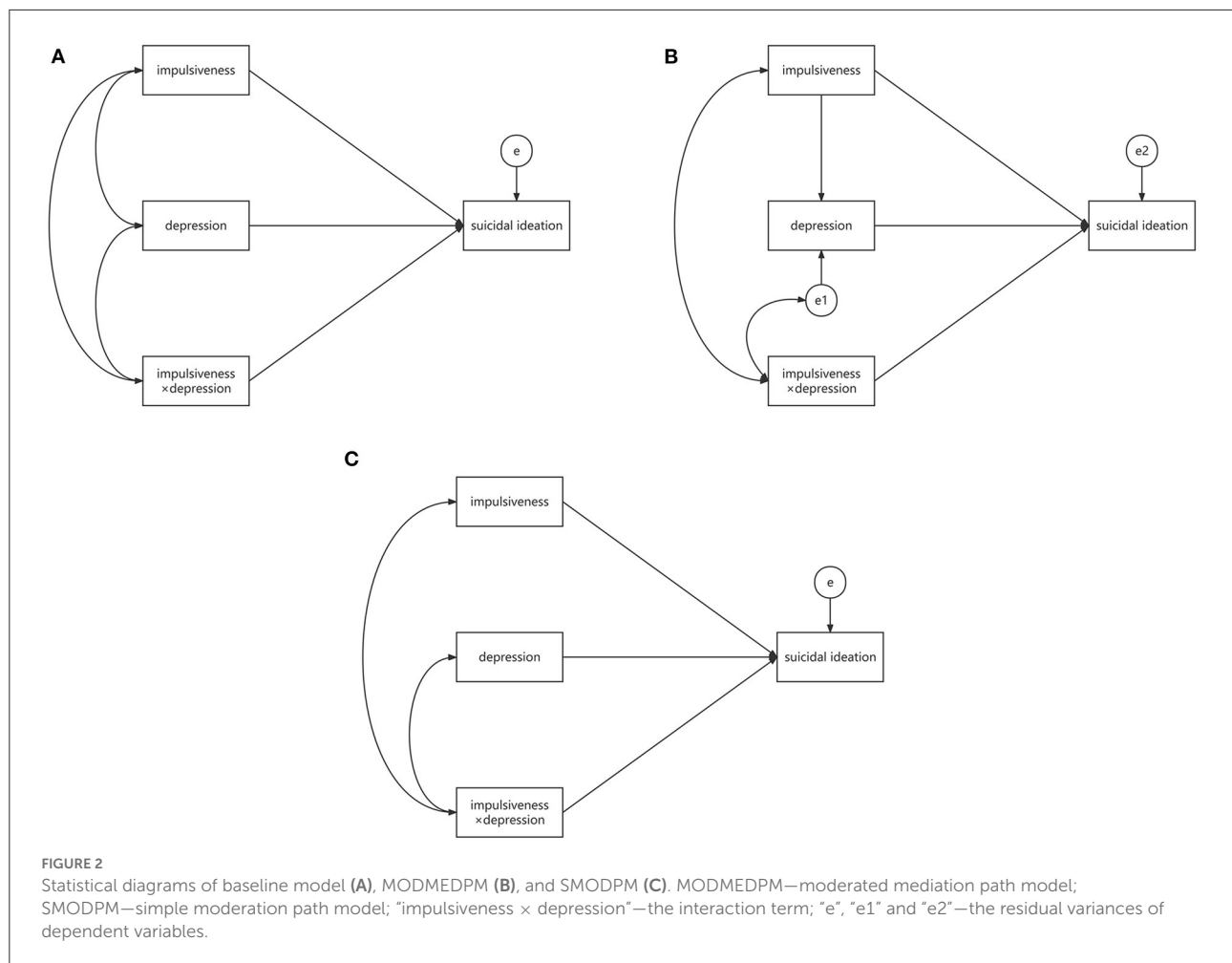
Statistical analyses

The internal consistency reliability coefficients and the correlation coefficients of the variables were calculated in SPSS 20.0 (37). We also made the descriptive statistics for demographic variables in SPSS 20.0. Model fits and path analyses were conducted in Mplus 8.3 (38). The Mplus code for mediation and moderation models was developed by Stride et al. (39), according to Hayes' PROCESS macro program documentation (40). We modified the Mplus code for adjusting the purpose of the present study.

Firstly, we constructed a baseline model, which was a saturated model with all variables (impulsiveness, depression, interaction term of impulsiveness and depression, and suicidal ideation) linked by paths (statistical diagram shown in Figure 2A). Secondly, we chose MODMEDPM, which was defined Model 74 (statistical diagram shown in Figure 2B) in PROCESS macro (40), as the target model. Model 1 (statistical diagram shown in Figure 2C) in PROCESS (40), which was SMODPM, was chosen as the alternative model.

The indexes of chi-square value, Akaike information criterion (AIC), Bayesian information criterion (BIC), comparative fit index (CFI), Tucker & Lewis index (TLI) and root mean square error of approximation (RMSEA) were used to compare the model fits. The level of significant tests for the paths was set to 0.05. The mediating effect was examined with the bootstrap method with a sampling size of 5,000. The scores of the three variables, including impulsiveness, depression, and suicidal ideation, were mean centered before modeling.

Results

Correlation matrix of impulsiveness, depression, and suicidal ideation

Mean centered scores were used when doing correlation analyses. Given that the scores of SIOSS did not fit a normal distribution (Kolmogorov-Smirnov $Z = 2.770$, $p < 0.001$), we performed correlation matrix with spearman coefficients. The

TABLE 2 Correlation matrix of the scores of BIS, SDS and SIOSS.

		BIS	SDS	SIOSS
BIS	Spearman coefficient	1.000		
	p	N/A		
SDS	Spearman coefficient	0.633	1.000	
	p	<0.001	N/A	
SIOSS	Spearman coefficient	0.476	0.726	1.000
	p	<0.001	<0.001	N/A

BIS, Barratt impulsiveness scale; SDS, self-rating depression scale; SIOSS, self-rating idea of suicide scale.

results showed that all the three variables were correlated with each other significantly, as shown in Table 2. The correlation matrix showed large correlation coefficients between depression and suicidal ideation ($r = 0.726$, $p < 0.001$), as well as between impulsiveness and depression ($r = 0.633$, $p < 0.001$). From the perspective of psychometrics, there are several items as observed indicators of the three variables presenting similar meanings, which may result in strong correlations of depression with impulsiveness and suicidal ideation. Considering the possible serious common method biases, we conducted a test and got the first common factor's explained variation as 24.31% [50%, as an empirical value in previous studies (41), was recommended the upper cut-off value of serious common method biases]. It meant that the common method biases in this study was tolerable. Therefore, the study results could illustrate the real relationships among variables.

Model optimization

Although suicidal ideation scores did not fit normal distribution, its coefficients of skewness (=1.027) and kurtosis (=0.943) were lower than 2 and 7, respectively. According to Finney and DiStefano's estimating strategy for model parameters (42), maximum likelihood (ML) estimation could still be used as a robust method. In addition, the bootstrap method might help solve the non-normal distribution problem.

The baseline model (Model 0) fit indexes showed that it was a saturated model with chi-square value and degrees of freedom equal to zero. Because moderation model hypothesized that the independent and moderating variable were not correlated with each other, we deleted the linkage between depression and impulsiveness and got the SMODPM (Model 1). However, the fit indexes of SMODPM were not good, as shown in Table 3. Then, we examined the target model MODMEDPM (Model 2). Model 2 was an algebraically equivalence model of Model 0 but was theoretically different. In Model 2, the path between impulsiveness and depression was unidirectional, while in Model 0, the path was bidirectional. Obviously, only Model 2

represented the mediation hypothesis. However, the fit indexes of Model 2 were the same with Model 0, which referred to a saturated model (see Table 3). The diagram and path coefficients were displayed in Figure 3. To optimize the model fit, we deleted the non-significant paths, namely, bidirectional path between impulsiveness × depression and impulsiveness (β = 0.117, SE = 0.116, $p = 0.312$), bidirectional path between impulsiveness × depression and e1 (β = 0.080, SE = 0.065, $p = 0.219$), and unidirectional path from impulsiveness to suicidal ideation (β = −0.010, SE = 0.046, $p = 0.829$). The Resulted Model 3 fitted well and could be accepted (indexes shown in Table 3). Finally, we included the demographic factors as covariates to control the confounding effects and resulted in Model 4, which fit better than Model 3 (see Table 3). None of the covariates had significant effect on dependent variables.

Moderated mediating effect analyses

Total effect

In the model, there were two nested models. Depression and suicidal ideation were the dependent variables in the two nested models, respectively. Depression was predicted by impulsiveness ($R^2 = 0.465$, SE = 0.043, $p < 0.001$). Suicidal ideation was directly predicted by depression and indirectly predicted by impulsiveness. Meanwhile, the indirect effect was moderated by impulsiveness ($R^2 = 0.551$, SE = 0.031, $p < 0.001$). This meant that the model could account for 55.1% of the total variances of suicidal ideation. The model summary was listed in Supplementary Table S1.

Mediating effect

As shown in Supplementary Table S2, the direct effect of impulsiveness on suicidal ideation was non-significant. The effects of impulsiveness on depression and of depression on suicidal ideation were significant [$\beta_{ondepression} = 0.680$, SE=0.032, 95%CI = (0.609, 0.737), $\beta_{onsuicidalideation} = 0.733$ SE = 0.022, 95%CI = (0.688, 0.773)], and the indirect effect of impulsiveness on suicidal ideation was significant [$\beta_{indirect} = 0.499$, SE = 0.031, 95%CI = (0.436, 0.558)]. The indirect effect here could be explained as mediating effect because all the significant coefficients were positive.

Moderating effect

We regarded the coefficient of path from the interaction term to suicidal ideation as the effect parameter of moderation [$\beta_{moderation} = 0.115$, SE = 0.027, 95%CI = (0.059, 0.167)]. However, this coefficient really represented the moderating effect on the path from depression to suicidal ideation. To test the moderating effect of impulsiveness on the indirect effect from impulsiveness to suicidal ideation, the conditional

TABLE 3 Fit indexes of the models.

Model	χ^2/df, p	RMSEA, 90%CI	CFI/TLI	AIC/BIC
Model 0	0.000/0, 0.000	0.000, (0.000, 0.000)	1.000/1.000	15,914.878/15,973.311
Model 1	297.092/1, 0.000	0.785, (0.712, 0.862)	0.240/-1.279	16,209.971/16,264.230
Model 2	0.000/0, 0.000	0.000, (0.000, 0.000)	1.000/1.000	15,914.878/15,973.311
Model 3	9.842/3, 0.020	0.069, (0.024, 0.119)	0.990/0.983	15,918.720/15,964.632
Model 4	22.024/15, 0.107	0.031, (0.000, 0.057)	0.990/0.988	15,877.217/15,973.118

As recommended by Wen and Marsh (43), when sample size was between 250 and 500, the significant level for chi-square test was set to be 0.0005. The p value larger than 0.0005 indicated a good fit. Additionally, the recommended good fit standards of RMSEA, CFI and TLI were <0.08, >0.90, and >0.90, respectively. AIC and BIC were used to compare models, and lower values indicated a better fit. "χ^2", chi-square; "df", degree of freedom; RMSEA, root mean square error of approximation; 90%CI, 90% confidence interval; CFI, comparative fit index; TLI, Tucker & Lewis index; AIC, Akaike information criterion; BIC, Bayesian information criterion.

FIGURE 3
Statistical diagrams of saturated MODMEDPM [(A), Model 2], relatively acceptable MODMEDPM [(B), Model 3], and final MODMEDPM [(C), Model 4]. ***p < 0.001; MODMEDPM—moderated mediation path model; "impulsiveness × depression"—the interaction term; "e," "e1," and "e2"—the residual variances of dependent variables; Covariates included gender, grade, residence, only child, family structure and age. The path coefficients were standardized.

indirect effect analysis (simple slope analysis) was conducted. Firstly, impulsiveness was divided into three conditions: low impulsiveness (mean-1SD), medium impulsiveness (mean), and high impulsiveness (mean + 1SD). Secondly, we calculated the simple slopes, which represented the moderated mediating effects, under the three conditions, respectively. Thirdly, we compared the three slopes to define whether they were statistically different. As these were multiple comparisons, the significant level was set to be 0.05/3 = 0.017. The results showed that the slope under the condition of high impulsiveness

FIGURE 4
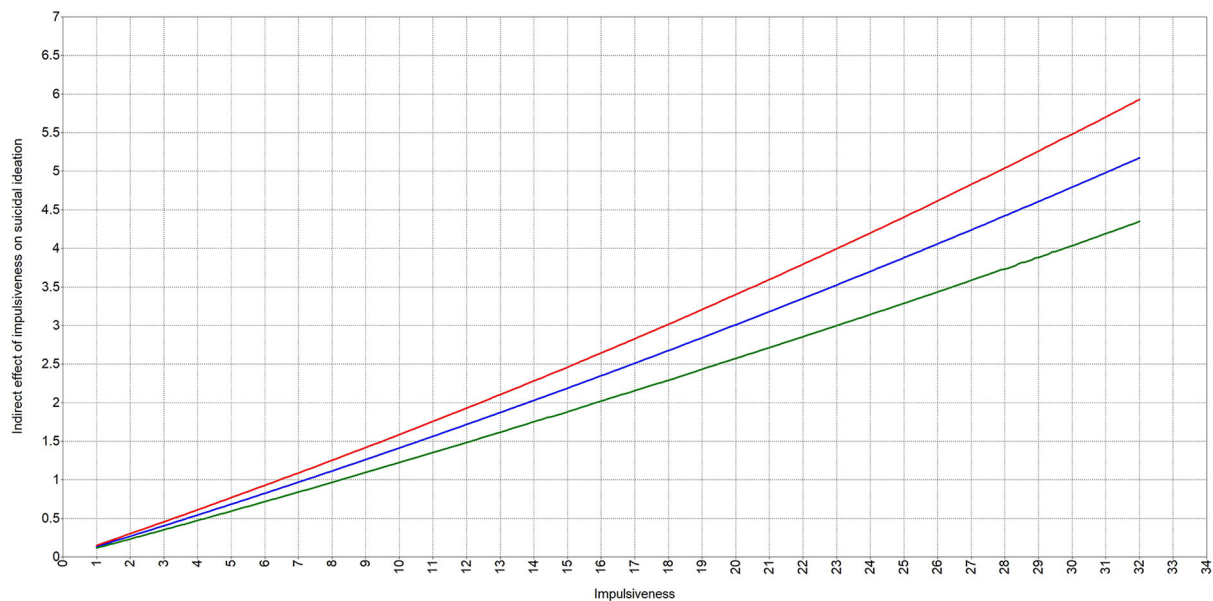Simple slope diagram. Red line—the indirect effect curve under condition of high impulsiveness; Blue line—the indirect effect curve under condition of medium impulsiveness; Green line—the indirect effect curve under condition of low impulsiveness.

was higher than that under the condition of medium and low impulsiveness ($\Delta\text{Slope}_{\text{High}-\text{Low}} = 0.028$, SE $= 0.008$, $p < 0.001$; $\Delta\text{Slope}_{\text{High}-\text{Medium}} = 0.014$, SE $= 0.004$, $p < 0.001$), and the slope under the condition of medium impulsiveness was higher than that under the condition of low impulsiveness ($\Delta\text{Slope}_{\text{Medium}-\text{Low}} = 0.014$, SE $= 0.004$, $p < 0.001$, see Supplementary Table S3). The simple slope diagram was shown in Figure 4. It indicated that impulsiveness positively moderated the indirect effect of impulsiveness on suicidal ideation. In other words, the mediating effect of depression between impulsiveness and suicidal ideation was reinforced by impulsiveness.

Discussion

In the present study, we found that the moderated mediation path model could finely describe the complex relationships among impulsiveness, depression, and suicidal ideation. Impulsiveness could indirectly lead to suicidal ideation through depression and enhance the indirect effect. These findings confirmed the hypothesis. Additionally, we found that impulsiveness did not affect suicidal ideation directly nor independently, and the presence of depression was necessary as both mediating and interacting variable.

Although impulsiveness was correlated with suicidal ideation in correlation matrix, the direct path from impulsiveness to suicidal ideation was not significant in

the model. In a word, it can be explained as the complete mediating effect. This indicates that impulsiveness probably predicts depression and depression sequentially predicts suicidal ideation. It partly illustrates the mechanism of impulsiveness' effect on suicidal ideation. Impulsiveness in motivational-volitional model is not among the risk factors for suicidal ideation (5). This theoretical hypothesis was verified in model-based studies in which depression was included (13, 14), which might be due to the strong mediating effect. Therefore, conclusion can be drawn that impulsiveness is an indirect risk factor for suicidal ideation. We had noticed that the coefficient of the direct path was negative. In some studies (44–46), this kind of indirect effect is named suppressing effect. Nevertheless, it is based on the condition that the coefficient is significant. In the present study, the coefficient of direct effect from impulsiveness to suicidal ideation was far away from significance (there was 82.9% of probability for us to accept the null hypothesis). We tend to regard it as random error rather than a real effect.

The mediating effect indicates that depression is an important bridge between impulsiveness and suicidal ideation. On one hand, depression is a vital cause for suicidal ideation, which has been proved in previous studies, but with different interpretations [e.g., hopelessness (47), psychological pain (48), impaired executive function (49), and lack of pleasure (50, 51)]. On the other hand, depression is proved related to impulsiveness (20, 52, 53). In the present study, impulsiveness was scaled as a trait, thus logically pre-existed compared to depression. There

was also a study confirming that depression was an outcome of impulsiveness, in which longitudinal designed observation was applied (54). Therefore, impulsiveness predicts depression. The bridge role of depression does not agree with the clinical diathesis-stress model (9), in which depression interacts with impulsiveness. It may not be reasonable to regard depression as stress itself, but a consequence when stress occurred, as is hypothesized in Beck's cognitive model (4).

Simultaneously, impulsiveness is the moderator for the mediating effect of impulsiveness on suicidal ideation through depression. Previous studies (55, 56) has discussed the moderating effect of impulsiveness between depression and suicidal ideation, finding that high level of impulsiveness can increase the depression's effect on suicidal ideation, which agrees with the present study. However, they do not consider the correlation between impulsiveness and depression, which exists and can lead to biases in the moderating effect analyses. Combining these two kinds of effects, we construct the well-fitted moderated mediating model, and illustrate the importance of both impulsiveness and depression in the generating of suicidal ideation. Depression is the necessary mediator between impulsiveness and suicidal ideation. Without depression, impulsiveness may not generate suicidal ideation directly. The precondition of impulsiveness leading to depression may be the existence of stress, in accordance with Beck's cognitive model of suicide (4). Impulsiveness is the reinforcer of its indirect effect on suicidal ideation. Therefore, impulsiveness is vital in generating of suicidal ideation, although it does not contribute to this process independently nor directly.

Some previous studies have proved that age is an important factor of impulsiveness (57, 58). Compared to the adults, adolescents are more impulsive (57, 58). The underlie mechanism may be the "ongoing maturation of parietal brain areas in adolescents" (58). Therefore, age's influence on impulsiveness may be the result of brain development. In the present study, to control the possible confounding effects of age, we only recruited participants who are adolescents and young adults aged from 16 to 21. According to the previous studies (57, 58), they might be more susceptible to impulsiveness than older adults. It is not clear whether the present results can be generalized to individuals of other age groups, which needs more considerations in future studies.

There are still some limitations of this study. First, we do not consider stress in this model, which is probably the moderator of impulsiveness' effect on depression and suicidal ideation. Second, the cross-sectional design cannot interpret the real causal relationships among impulsiveness, depression, and suicidal ideation. We only construct the unidirectional path model based on theoretical analyses. In fact, there are studies (59, 60) show that depression as a trait (e.g., the depressive component of affective temperament) can also predict suicide behaviors. This indicates that depression is not always the

outcome of impulsiveness but may overlap with it on the trait level. What roles impulsiveness and depression play in generating suicidal thoughts and behaviors needs more evidence from longitudinal studies. Third, the sample comes from college students. It is not clear whether the results could be generalized to a more widely range of populations. Future studies would include both stress and depressive trait as the predictors and conduct longitudinal design to optimize the model. Meanwhile, more participants of different age, social status, occupations, and ethnics can be included for unbiased results.

Conclusions

The present study finds that impulsiveness indirectly affects suicidal ideation through the mediator depression, and simultaneously moderates the mediating effect. This implies first that people who have impulsive traits are riskier to generate suicidal thoughts because they are more likely to suffer from depression. Second, people who are depressive have even higher risk to develop suicidal thoughts when they simultaneously have impulsive traits. Therefore, in clinical and health care work, when considering depression to prevent suicidal ideation, impulsiveness needs to be monitored throughout the process of premorbid and onset stages of depression.

Data availability statement

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

Ethics statement

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

Author contributions

JZ contributed to the design of the research, conducting statistical analyses, and drafting the manuscript. XZ contributed to the arranging of materials and data, conducting statistical analyses, and editing manuscript. GY contributed to the data processing and manuscript revising. ZF contributed to the design of the whole study and critical revising of the manuscript. All authors have read and revised the final manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.913680/full#supplementary-material

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Concern on cyber violence and suicide during COVID-19 pandemic

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Introduction

Three days after delivering food to her father, she jumped to her death. It started when a storm of public opinion erupted after she gave the delivery man $30.76 for his kindness. This real case occurred during the COVID-19 pandemic in Shanghai in April 2022. The girl, who had a happy family and was physically and mentally healthy, shared her heartwarming story on her Micro-blog, thanking the delivery man for his selfless act. However, this "small" incident cost her life.

Previous studies have shown a significantly rise in suicide rates during the COVID-19 pandemic (1, 2). In addition, current research indicates that cyber violence is closely associated with a higher risk of suicidal behavior (3, 4). Under the double pressure of epidemic and cyber violence, such tragic events are by no means negligible. Relevant departments should step up network security monitoring, timely block the injury of cyber violence to the victims, and provide psychological intervention for the victims of cyber violence, in order to prevent the occurrence of suicide.

Cyber violence is toxic to society. It refers to the illegal and criminal behavior by which individuals or groups intentionally spread illegal information through the Internet to repeatedly and continuously infringe on specific individuals or groups, which will lower the social evaluation of the attacked individuals, infringe on the right of personality and information, and even threaten the rights of person and property (5). The perpetrators of cyber violence have a degree of anonymity that traditional bullying does not, and the potential exposure and embarrassment for victims is greater. Day or night, in their own homes or anywhere else, harm can be done to victims, and the information accumulates even when they leave the Internet. Victims of cyber violence often have mental health problems, including symptoms of depression, anxiety, and self-harm, up to suicide (6). Previous study revealed that the prevalence of cyber violence ranged up from 6 to 35% before the epidemic (7). However, cyber violence has increased significantly during the pandemic (8).

Shadows of the pandemic: Cyber violence and suicide

In the early days of the COVID-19 pandemic, The Lancet Psychiatry Commission predicted an increase in suicide rates worldwide (9). Significantly, a critical review went on to confirm this revelation that rates of suicidal ideation during the COVID-19 pandemic were higher than those reported in pre-pandemic studies of the general population (1, 2). Moreover, women need special support for higher risks of suicidal behavior during the pandemic, as they are at greater risk of unemployment, have heavier family burdens and face more violence from their families or society during lockdowns and crises (10).

The United Nations has identified violence against women (VAW) as a shadow pandemic created in the midst of the COVID-19 pandemic. Previous literature indicated that the incidence of cyber violence against female victims was significantly higher than that against males (11), and cyber violence was closely associated with increased suicidal ideation (12). Looking at cyber violence as a form of VAW during the pandemic, a recent study found that almost 25% of respondents frequently observed different forms of cyber violence against women and girls (13). While cyber violence against women significantly increased during the pandemic (14), there were few rigorous studies on the relationship between the COVID-19 pandemic and VAW. Data from those studies consisted mostly of articles published in comments, editorials, and letters from social media, the Internet, and helpline reports. Research on the COVID-19 pandemic and cyber violence is even rarer.

A review that included reports from 53 WHO European member states found that the most common measure to prevent or respond to VAW was to use social media to raise awareness of violence among female victims and to provide services to them through online platforms, followed by measures to expand or maintain helpline services for female victims of violence (15). Some people may not seek help because they fear that face-to-face appointments could put them at risk and emergency services are overwhelmed in the pandemic. Additionally, due to the anonymity of cyber violence and the complexity of obtaining evidence (16), it is quite difficult to establish the rights protections of victims themselves or the jurisdiction of law enforcement departments. Others may look for help from crisis helplines in the government sector, which are likely to be overwhelmed by a surge in calls and shortage of service personnel.

Discussion

In this case, the suicide occurred just 2 days after the outbreak of cyber violence. It can be seen that the intervention of suicidal behavior lacks timeliness. During the COVID-19 pandemic, the incidence of cyber violence and suicide has increased, respectively (17, 18). It is hoped that concerted efforts will be made to prevent the occurrence of adverse events related to cyber violence. Unfortunately, little research has been done on the relationship between these two issues. There are several recommendations of our paper: Online entertainment websites and platforms, while seeking to maximize their products, should fulfill their moral responsibilities by controlling online content, formulating and publicizing internet anti-abuse policies, regularly testing their impact, and investigating whether users have recently suffered from cyber violence, so as to point out a direction for users' psychological support. For the general public, it is necessary to control unnecessary Internet use time, carry out more offline physical exercise, and maintain good peer and family relations (7). We should strictly take legal action or hold perpetrators accountable, provide psychological support to victims and witnesses in a timely manner, and try our best to ease their psychological trauma. All health professionals, especially those in mental health, should do their best to educate clients and families about steps to stay Internet-use safe and take timely intervention for the victims. Mental health services should develop clear pathways for remote assessment and care, and train staff in new ways of working during an epidemic to provide timely and effective interventions for people at risk of suicide. At the same time, at the national level, online resources and psychological interventions should be provided and promoted free of charge on a large scale for the basic mental health of the vast population (9). Health care systems should facilitate further investigation into the relationship between violence against women, especially cyber violence, and COVID-19 to identify creative solutions to deliver clinical care and medical services to the victims.

Public health implications

The issue of cyber violence during the pandemic is extremely important and cannot be ignored. Relevant departments need to formulate rigorous and effective measures to reduce the suicide caused by it.

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HL originally designed the study and have been responsible for obtaining funding. All authors contributed to this study, read the manuscript, approved the final manuscript, interpretation of data, and the approval of the final report.

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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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Social media use and body image issues among adolescents in a vulnerable Louisiana community

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Widespread concern has been expressed regarding unrealistic body image and adolescent eating disorder promoting content on social media (SM) platforms. Numerous research studies have examined the impact of SM on body image as well as social vulnerability on negative mental health outcomes. Despite this, few previous studies have examined the impact of SM on body image specifically in vulnerable, underserved, or predominantly minority communities. This study examines the impact of SM on body image issues (BII) in adolescents in a public school system where greater than 50% of the students live in impoverished households. In late 2019, high school student leaders in Northwest Louisiana developed a survey alongside Step Forward, a collective impact initiative. Questions investigated adolescent SM use and mental health in Caddo Parish, namely BII. Teachers within Caddo Parish Public School System administered the survey. Out of the 11,248 total high school students in the school system, nearly 50% were sampled for a sample size of 5,070. Hypotheses included: (1) females were more likely to use SM than males, (2) increasing time spent on SM would correlate with females reporting BII, with males remaining largely unaffected, and (3) highly visual social media (HVSM) platforms would be associated with greater reports of BII than non-HVSM platforms. Results showed females were more likely to use SM ($p < 0.001$) and report BII ($p < 0.001$) compared to males, while both sexes reported BII with increasing time spent on SM ($p < 0.001$). A diversity of platforms were associated with increased BII among SM users compared to non-users ($p < 0.001$): Pinterest, Reddit, Snapchat, TikTok, Twitter, and YouTube. This conclusion is tempered by the omission of race as a variable

in the study design, the use of self-report, and the use of an unvalidated instrument. These findings suggest that the harmful association between SM use and BII may transcend culture and socioeconomic status for a broadly deleterious effect on adolescent mental wellbeing.

Introduction

Adolescent vulnerability to mental health disorders

Previous studies have seen an association between heightened vulnerability to outside influences and the advent of puberty. Given the magnified sensitivity of this time, adolescents may be susceptible to mental health insults, with around 20% of children and adolescents experiencing some sort of struggle with mental wellbeing (1), and nearly 50% of those having developed signs and symptoms as early as 14 years of age (2, 3). Additionally, the prevalence of mood disorders increases with age, with rates nearly doubling from the age ranges of 13–14 to 17–18 years old (4). The most common mood disorders experienced by these populations are anxiety and depression, with nearly one in three adolescents suffering from some form of anxiety disorder. Furthermore, Kessler et al. found the prevalence of any diagnosable mental health or behavioral disorder in the adolescent population to be 23.4%, representing nearly a quarter of the entire adolescent population suffering mentally (2).

Body image issues among adolescents

The phrase "body image" encompasses how one perceives, acts toward, thinks, and feels about one's body and lies on a spectrum ranging from positive to negative perceptions (5). Adolescents, especially females, have historically been subjected to pressures in favor of the thin body image ideal in traditional media outlets; this problem is suspected of growing more severe with the rise of social media (SM) (6).

On average, 50% of adolescent females are unhappy with their bodies compared to 31% of males (7). Generally speaking, the media portrays several ideal body images for females, ranging from curvy and hourglass, to thin, to athletic and muscular (8–12). Meanwhile, males seem to receive a more consistent message that muscular is ideal (1).

Impact of social media

Of all media outlets, SM may represent the strongest driver of these beauty ideals. SM platforms, such as Facebook, Instagram, Snapchat, and TikTok, among others, are used ubiquitously among U.S. adolescents, with 96% using at least one social networking platform (13, 14). There are differences between and among adolescents in their usage patterns, with 35% of adolescents of African descent indicating that they "enjoy using social media a lot" as opposed to 20% of adolescents of European descent. Adolescents of African descent also average 36% more time on SM compared to adolescents of European descent. In addition, in 2019 average daily screen use among adolescents of African Descent was 8.32 h compared to 6.40 h for adolescents of European descent (15).

SM platforms can be broadly divided into highly visual social media (HVSM) and others. HVSM includes Instagram, Snapchat, Pinterest, YouTube, and TikTok, among others in the minority. The "other" group is largely comprised of Facebook, Twitter, and Reddit. HVSM are often accompanied by interactive features such as likes, comments, and stories. McCrory et al., described these features as contributing to severe emotional highs and lows associated with instant gratification and instant inadequacy, respectively (16). It has been reported that females are disproportionately likely to use HVSM, with males tending to gravitate toward Facebook (17).

SM has enabled the widespread viewing of "ideal body image" content, with recent research indicating that up to 80% of photographs are digitally altered (18). Data from several SM platforms shows that they consistently reinforce these body image ideals and may facilitate poor body image, perception of self, and eating disorders among males and females (19, 20). Adolescents, especially females, have reported they received mostly negative insight about their bodies and perceived sexual attractiveness from SM, spurring body and self-dissatisfaction (21, 22). Furthermore, screen time on SM has been linked to obesity, perpetuating the unrealistic nature of the beauty standards portrayed on platforms. Body dissatisfaction has been strongly linked to associated symptoms of anxiety and depression, with data showing females at an increased risk,

perhaps due to increased use of highly visual SM as compared to males (17, 23).

Additional studies examining time on SM have found that adolescents using SM for more than 2 h a day were more likely to report body image issues (BII), eating concerns, and depression (17, 24–26). This combination of time spent on SM and increased reliance on HVSM by females may serve as a potential reason why females appear to be more susceptible to BII compared to males (17).

Caddo Parish population profile

These topics are especially relevant in the community of Northwest Louisiana, specifically Caddo Parish (county). Caddo Parish is located in the Northwest corner of Louisiana, bordering Texas and Arkansas. It is the fourth largest parish in Louisiana, containing three of the poorest zip codes in the state that are home to approximately 96,000 families. Caddo Parish is home to a population of about 240,000, comprised of 50% Americans of African descent, 46.5% Americans of European descent, 2.9% Hispanic Americans, and 1.3% Americans of Asian descent, with a median household income of $41,797 (27). Students of Caddo Parish Public Schools are comprised of 80% social minority populations, with 63.2% Americans of African descent, 32% Americans of European descent, and 4% of students from other races (28, 29). Furthermore, 54% of students in the school system are eligible to receive free and reduced lunch, an indicator of lower family income (30–32).

Depending on the year, Louisiana oscillates between ranking first and second nationwide in children living in poverty (33, 34). Caddo Parish is one of the most economically segregated regions in the South, with approximately 21% of families living below the poverty level (35). Childhood and adolescent adversity are often interrelated with poverty.

Louisiana ranked 50th among the states with the worst health outcomes in the United States (34). Louisiana ranks second in worst states for healthcare and ranks well above the national average for obesity and hypertension (34, 36–38). Specifically Shreveport, the largest city within Caddo Parish, ranks eighth in most obese cities nationwide (39). The state ranks 46th in public healthcare, and, finally, 49th in mental healthcare and mental health outcomes (34, 40).

These environmental factors expose the vulnerable adolescent population to significant stressors early in life, putting them at higher risk for physical harm and mental disability. According to the Child and Adolescent Health Initiative, 25.2% of Louisiana children had two or more adverse childhood experiences in 2016 (41). Studies show that exposure to extreme life stressors, such as childhood maltreatment, leave adolescents vulnerable to mood disorders, substance use disorders, impaired immune function, and generally poor health-seeking behaviors (42–44). These data portray a

landscape ripe for mental health vulnerability and susceptibility to negative influences, highlighting the need for further data on other factors' influence, such as SM, on adolescent mental health in areas with multi-generational poverty, violence, and social neglect (45).

In 2020, slightly more than 50% of Caddo Parish 10th grade students reported feeling depressed or sad most days in the past year and 35% met criteria for needing mental health treatment. This represents a 19% increase from the previous (2018) survey (1, 46).

Field contribution

A National Library of Medicine electronic (PubMed) search conducted using the principal keywords—"social media," "adolescents," "body image," and "disparities"— revealed four articles and a gap in the literature. Removing "disparities" resulted in numerous distinct results involving SM and BII in populations of young adults, Latinx, British, and Australian participants. However, no other study has assessed a population wherein the preponderance of children across an entire parish that is majority Americans of African descent or that ranks in the highest percentile for social vulnerability (47–50). Furthermore, this is the first study to examine the impact of BII in adolescents in a public school system where greater than 50% of the students live in impoverished households (31, 32, 51). Lastly, no previous studies have looked at impoverished adolescents with a sample size of such magnitude; the others of similar size focus on 18 years and older or neglect to account for social minority populations (50, 52–54).

Hypotheses

We hypothesized that (1) females were more likely to use SM than males, (2) the more time spent on SM, the more likely females are to report BII, with males remaining largely unaffected, and (3) HVSM platforms are associated with greater reports of BII than non-HVSM platforms. These hypotheses may prove particularly acute for the disproportionately vulnerable adolescent community of Caddo Parish. With the onset of COVID-19, this conversation proves increasingly relevant. Our novel findings may set a foundation for future studies in these areas and inspire future early adolescent mental health interventions, especially as SM use rises.

Materials and methods

Study design

This study design was developed by students from the Caddo Parish Public School System who recognized the mental

TABLE 1 Differences in social media (SM) use by sex.

	Total sample $N = 5,070$	Female $N = 2,753$	Male $N = 2,203$	P
I do not use social media				< 0.001
No	3,424 (67.5%)	2,064 (75.0%)	1,265 (57.4%)	
Yes	162 (3.2%)	63 (2.3%)	92 (4.2%)	
Facebook				< 0.001
No	2,756 (54.4%)	1,576 (57.2%)	1,100 (49.9%)	
Yes	830 (16.4%)	551 (20.0%)	257 (11.7%)	
Instagram				< 0.001
No	582 (11.5%)	269 (9.8%)	285 (12.9%)	
Yes	3,004 (59.3%)	1,858 (67.5%)	1,072 (48.7%)	
Pinterest				< 0.001
No	2,749 (54.2%)	1,390 (50.5%)	1,276 (57.9%)	
Yes	837 (16.5%)	737 (26.8%)	81 (3.7%)	
Reddit				< 0.001
No	3,242 (63.9%)	2,022 (73.4%)	1,137 (51.6%)	
Yes	344 (6.8%)	105 (3.8%)	220 (10.0%)	
Snapchat				< 0.001
No	1,142 (22.5%)	531 (19.3%)	562 (25.5%)	
Yes	2,444 (48.2%)	1,596 (58.0%)	795 (36.1%)	
TikTok				< 0.001
No	1,889 (37.3%)	908 (33.0%)	915 (41.5%)	
Yes	1,697 (33.5%)	1,219 (44.3%)	442 (20.1%)	
Twitter				0.97
No	2,587 (51.0%)	1,535 (55.8%)	980 (44.5%)	
Yes	999 (19.7%)	592 (21.5%)	377 (17.1%)	
YouTube				0.54
No	872 (17.2%)	512 (18.6%)	339 (15.4%)	
Yes	2,714 (53.5%)	1,615 (58.7%)	1,018 (46.2%)	
Other social media				< 0.001
No	3,386 (66.8%)	2,044 (74.2%)	1,256 (57.0%)	
Yes	200 (3.9%)	83 (3.0%)	101 (4.6%)	
Number of social media platforms used, mean (SD)	3.69 (1.85)	3.99 (1.76)	3.24 (1.86)	< 0.001
Time spent on social media daily				< 0.001
Less than 1 h	493 (9.7%)	222 (8.1%)	253 (11.5%)	
1–2 h	918 (18.1%)	525 (19.1%)	371 (16.8%)	
More than 2 h	2,135 (42.1%)	1,367 (49.7%)	706 (32.0%)	

health crisis of their peers. These students felt SM to be a significant effector and perpetuator of BII and mental illness in their community. In response, during the spring of 2019, the Step Forward Teen Advisory Committee (TAC) was established to allow local adolescents to share their perspectives and knowledge of the needs of youth in Northwest Louisiana.

Step Forward represents a collective impact initiative of the Community Foundation of Northwest Louisiana. Their mission is to ensure optimal conditions of success for every individual from infancy to career in Northwest Louisiana. The TAC served as advisors to Step Forward community leaders in the process of identifying central focus areas and creating action plans geared toward improving student outcomes.

The TAC identified three key objectives for Northwest Louisiana youth: (1) improve teen mental health, (2) increase diverse career training opportunities, (3) increase youth civic involvement. In addition, the TAC wanted to understand the current state of adolescent mental health in Northwest Louisiana. Believing there may be a crisis with this population, they set out to collect data that accurately reflected the mental health landscape of Northwest Louisiana adolescents.

The TAC recommended specific question areas to Step Forward staff to create a survey instrument. The instrument consisted of 15 questions targeted at understanding teen mental wellbeing. Questions were asked about participants' age and gender, use of SM, access to and utilization of support

TABLE 2 Differences in social media (SM) use by self-report of body image issues (BII).

	Total sample N = 5,070	No BII N = 2,448	BII N = 1,192	P
Age (years), mean (SD)	15.79 (1.23)	15.76 (1.22)	15.83 (1.22)	0.14
Gender				< 0.001
Female	2,753 (54.3%)	1,236 (50.5%)	925 (77.6%)	
Male	2,203 (43.5%)	1,159 (47.3%)	215 (18.0%)	
Other	114 (2.3%)	53 (2.2%)	52 (4.4%)	
Do not use social media				0.021
No	3,424 (67.5%)	2,252 (92.0%)	1,132 (95.0%)	
Yes	162 (3.2%)	122 (5.0%)	40 (3.4%)	
Facebook				0.037
No	2,756 (54.4%)	1,843 (75.3%)	873 (73.2%)	
Yes	830 (16.4%)	531 (21.7%)	299 (25.1%)	
Instagram				0.13
No	582 (11.5%)	378 (15.4%)	164 (13.8%)	
Yes	3,004 (59.3%)	1,996 (81.5%)	1,008 (84.6%)	
Missing	1,484 (29.3%)	74 (3.0%)	20 (1.7%)	
Pinterest				< 0.001
No	2,749 (54.2%)	1,959 (80.0%)	750 (62.9%)	
Yes	837 (16.5%)	415 (17.0%)	422 (35.4%)	
Reddit				< 0.001
No	3,242 (63.9%)	2,176 (88.9%)	1,026 (86.1%)	
Yes	344 (6.8%)	198 (8.1%)	146 (12.2%)	
Snapchat				< 0.001
No	1,142 (22.5%)	809 (33.0%)	293 (24.6%)	
Yes	2,444 (48.2%)	1,565 (63.9%)	879 (73.7%)	
TikTok				< 0.001
No	1,889 (37.3%)	1,373 (56.1%)	476 (39.9%)	
Yes	1,697 (33.5%)	1,001 (40.9%)	696 (58.4%)	
Twitter				< 0.001
No	2,587 (51.0%)	1,753 (71.6%)	794 (66.6%)	
Yes	999 (19.7%)	621 (25.4%)	378 (31.7%)	
YouTube				< 0.001
No	872 (17.2%)	613 (25.0%)	219 (18.4%)	
Yes	2,714 (53.5%)	1,761 (71.9%)	953 (79.9%)	
Other social media				< 0.001
No	3,386 (66.8%)	2,287 (93.4%)	1,099 (92.2%)	
Yes	200 (3.9%)	87 (3.6%)	73 (6.1%)	
Number of social media platforms used, mean (SD)	3.69 (1.85)	3.47 (1.76)	4.25 (1.87)	< 0.001
Time spent on social media daily				< 0.001
Less than 1 h	493 (9.7%)	385 (15.7%)	108 (9.1%)	
1– h	918 (18.1%)	645 (26.3%)	273 (22.9%)	
More than 2 h	2,135 (42.1%)	1,344 (54.9%)	791 (66.4%)	

systems, various challenges experienced, coping strategies to stressors, and community involvement. Permission was obtained from the Superintendent of Schools for Caddo Parish for survey initiation.

The instrument designers felt it important to provide respondents with terms that were familiar with or would readily understand when answering the survey. With this in mind, more generalizable terms such as "issues with body image" were employed. This phrase was used to capture the landscape of adolescent BII more broadly and to "rule in" respondents who may be affected rather than create more narrow, specific criteria that have the potential to "rule out" due to respondent incomprehension or non-identification with an unfamiliar language.

Data collection

During the 2019–2020 school year, there were 11,248 students enrolled in ten public high schools in Caddo Parish. The numbers of students per grade were as follows: 9th–3,156; 10th–2,802; 11th–2,666; 12th–2,624. Approximately 70% of Caddo students are economically disadvantaged with 71% identifying as a minority population and 29% identifying as white. Within the student population, 49.52% were female, and 50.48% were male. In the fall of 2019, the survey was available to English teachers in all 10 high schools in Caddo Parish to administer in their classes. Participation in the survey was voluntary, and parents were provided the opportunity to opt-out their children (55). Of the 11,248 high school students in Caddo Parish at the time of the survey, 5,070 respondents aged 14–19 years old, with a median age of 16, completed the survey. Because the survey was voluntary, participation was not tracked by the Caddo Parish Public Schools or school principals. We lack documentation of the specific schools and classes that participated in the survey. However, we believe that the volume of respondents is still sufficient to assign significance to the findings.

Later that year, TAC members worked with an expert consultant to analyze the data and provide a series of recommendations for improvement steps in students' mental health services. These findings and recommendations were presented by Step Forward and TAC representatives to the Caddo Parish School Board.

Data obtained from this survey illustrates students' beliefs regarding their own mental health. Topics of self-harm behavior, thoughts on confiding in someone beneficial, and BII were assessed. Analysis of this data allowed researchers to make inferences on various challenges faced by respondents, enabling the TAC team to better understand the mental health landscape of the Caddo Parish Public School system. At the beginning of 2020, Step Forward made this data set available to the broader research community with the intention of further data analysis for additional improvements in students' mental health services. Our research team at Louisiana Health Sciences Center completed an IRB and received approval for study initiation.

We used the data available to give a cross-sectional view of adolescent mental health in the Caddo Parish Public School system in Northwest Louisiana at the time of the survey. This paper focuses on the effect of SM usage on body image. An exploratory analysis was performed based on this objective.

Statistical analysis

Data management and statistical analysis were performed using STATA/BE v17 (StataCorp, LLC). Continuous variables are presented as mean standard deviation (SD). Categorical variables are presented as the number (proportion or %) of participants. All data were tested for normality using Kolmogorov-Smirnov test, and data that passed normality assumption were analyzed using Student's t-test ($p < 0.05$) for two groups. Categorical variables were analyzed using Pearson's Chi-squared test.

Unadjusted and adjusted association of gender and endpoints were analyzed using generalized logistic regression models for the entire dataset. All P-values are 2-sided, with $p < 0.05$ considered statistically significant.

Results

Participants

Out of the 11,248 total high school students in Caddo Parish Public School System, we sampled over 50% with a sample size of 5,070 (30). Respondents were predominately females (54.3%) with an average age of 15.79 ± 1.23 years.

Hypothesis 1

In Hypothesis 1, we hypothesized that females are more likely to use SM than males.

We found that only 3.2% of sampled adolescents reported not using SM ($p < 0.001$) (Table 1). A greater percentage of females reported using Facebook, Instagram, Pinterest, Snapchat, and TikTok than males ($p < 0.001$) (Table 1). A greater percentage of females reported using Twitter and Instagram than males, but results were not statistically significant. The only SM application used by males more than females was Reddit ($p < 0.001$) (Table 1). Further, females were more likely to spend two or more hours on SM per day as compared to males ($p < 0.001$) (Table 1).

Hypothesis 2

In Hypothesis 2, we hypothesized that the more time spent on SM, the more likely females are to report BII, with males remaining largely unaffected.

We found that 77.6% of females reported BII compared to 18% of males ($p < 0.001$) (Table 2). Females were about four times more likely to report experiencing BII compared to male participants with an odds ratio (OR) of 4.03 (95% confidence interval (CI) = 3.41–4.78, $p < 0.001$) (Table 3).

Students reporting a daily use of more than 2 h of SM have 1.59 more odds of self-reporting BII compared to those using less than 2 h daily (CI = 1.37–1.84, $p < 0.001$). Students who reported use of more than four SM platforms have two times greater odds of reporting BII than do those using less than four of these platforms (OR = 2.04, CI = 1.77–2.36,

$p < 0.001$) (Table 3). Most respondents used three or four SM apps (Figure 1), which corresponded to peak reports of BII (Table 3). Using five SM platforms increased self-reports of BII by about 30% and using six or seven platforms doubled reports of BII (Figure 1). Students who reported experiencing BII, were more likely to spend two or more hours a day on SM, as compared to those who did not report BII (Figure 2). After 2 h spent daily on SM platforms, BII reported in SM users increased from 23% of respondents to 66% of respondents. Contrary to our hypothesis, data showed both females and males to self-report BII in the setting of increased time using SM.

Hypothesis 3

In Hypothesis 3 we hypothesized that HVSM platforms are associated with greater reports of BII than non-HVSM platforms.

Pinterest, Snapchat, TikTok, and YouTube show a statistically significant difference in self-reporting BII (35.4, 73.7, 58.4, and 79.9%, respectively, with $p < 0.001$). The use of non-HVSM Facebook, Reddit, and Twitter also showed to be associated with self-reported BII (25.1%, $p = 0.037$; 12.2%, $p < 0.001$; 31.7%, $p < 0.001$, respectively). Use of Instagram does not show a statistically significant difference in self-reported BII with usage (84.6%, $p = 0.13$) (Table 2).

Pinterest showed the highest odds of self-reporting BII (OR = 2.66, 95% CI = 2.26–3.12, $p < 0.001$) followed by TikTok (OR = 2.01, 95% CI = 1.74–2.31, $p < 0.001$), Snapchat (OR = 1.55, 95% CI = 1.33–1.81, $p < 0.001$) and YouTube (OR = 1.51, 95% CI = 1.27–1.80, $p < 0.001$) (Table 3). Non-HVSM of Facebook and Twitter showed less odds of self-reporting BII while still remaining statistically significant (OR = 1.19, 95% CI = 1.01–1.40, $p = 0.038$; OR = 1.34, 95% CI = 1.15–1.57, $p < 0.001$). The use of Instagram was not statistically significant with self-reporting of BII in this sample of respondents (OR = 1.16; 95% CI = 0.95–1.42; $p = 0.133$). Not using SM was protective for self-reporting BII (OR = 0.65, 95% CI = 0.45–0.94, $p < 0.021$) (Table 3).

When stratified by sex, HVSM predictors showed increased odds of reporting BII in both females and males who use Pinterest (OR = 1.66, 95% CI = 1.38–1.99, $P < 0.001$ and OR = 3.31, 95% CI = 2.05–5.36, $P < 0.001$), YouTube (OR = 1.61, 95% CI = 1.31–1.99, $P < 0.001$ and OR = 1.51, 95% CI = 1.03–2.21, $P = 0.033$), and TikTok (OR = 1.65, 95% CI = 1.38–1.97, $P < 0.001$ and OR = 1.50, 95% CI = 1.11–2.03, $P < 0.01$). Snapchat was statistically significant for females (OR = 1.30, 95% CI = 1.06–1.59, $P < 0.05$) but not males (OR = 1.31, 95% CI = 0.96–1.78, $P = 0.09$) in association with BII reporting (Table 4). While the use of HVSM was more likely to result in reports of BII, our data was unable to make an association between HVSM and increased BII. A diversity of SM

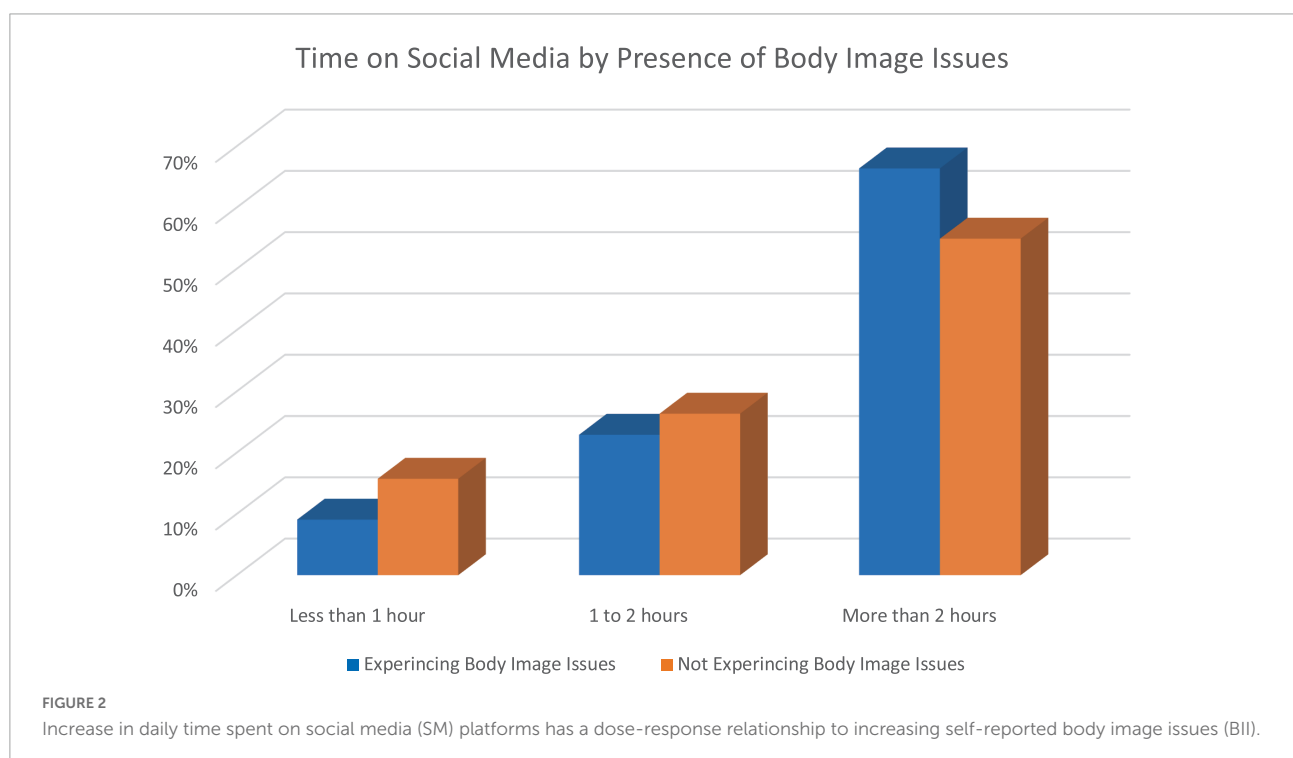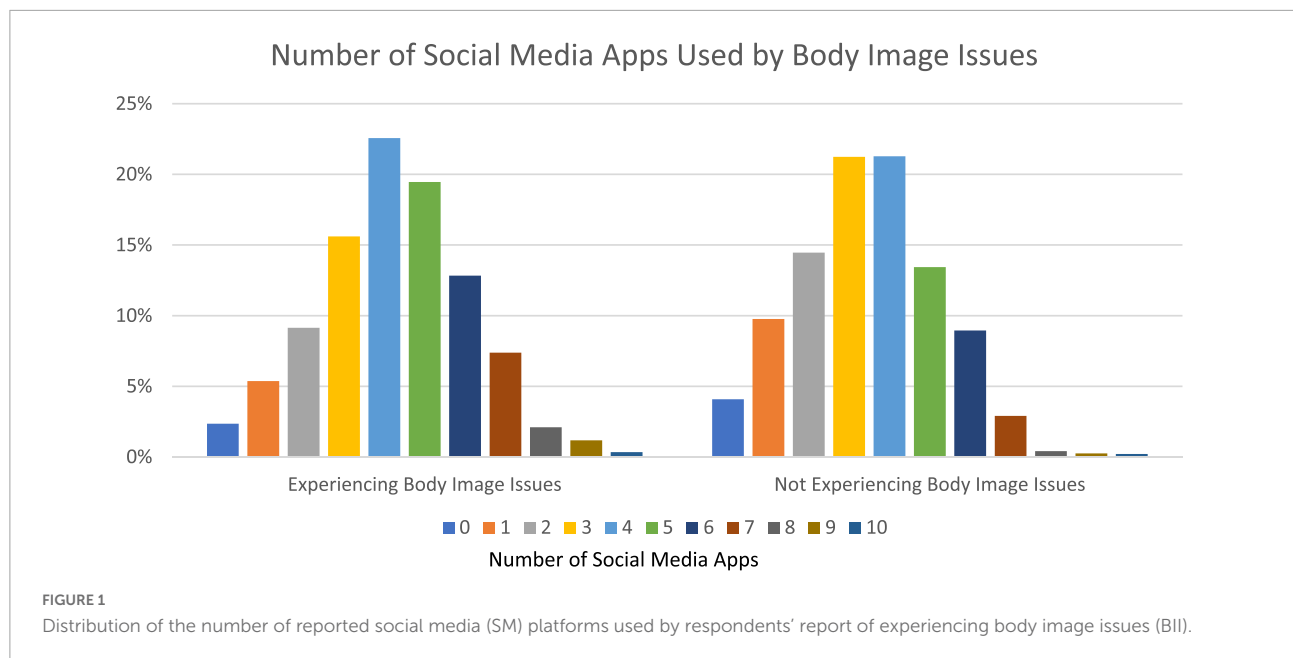TABLE 3 Odds ratios for self-reported body image issues (BII).

Predictors	OR	95% CI	P
Female vs. male	4.03	3.41–4.78	< 0.001
Social media			
No use	0.65	0.45–0.94	0.021
Facebook	1.19	1.01–1.40	0.038
Instagram	1.16	0.95–1.42	0.133
Pinterest	2.66	2.26–3.12	< 0.001
Reddit	1.56	1.25–1.96	< 0.001
Snapchat	1.55	1.33–1.81	< 0.001
TikTok	2.01	1.74–2.31	< 0.001
Twitter	1.34	1.15–1.57	< 0.001
YouTube	1.51	1.27–1.80	< 0.001
Other	1.75	1.27–2.40	0.001
Time spent on social media daily			
Less than 2 h (Reference)	1	–	–
More than 2 h	1.59	1.37–1.84	< 0.001
Number of social media platforms used			
Less than 4 platforms (Reference)	1	–	–
More than 4 platforms	2.04	1.77–2.36	< 0.001

platforms (both HVSM and non-HVSM) were associated with a statistically significant increase in BII among participants.

All predictors remained statistically significant after adjustment for sex differences, apart from "No use of SM" (OR = 0.80; 95% CI = 0.54–1.19; $p = 0.27$) and Facebook (OR = 1.05; 95% CI = 0.88–1.24; $p = 0.617$). Pinterest and Reddit were among the strongest contributors to BII, with OR = 1.79 (CI = 1.51–2.13; $p < 0.001$) and OR = 2.85 (CI = 2.19–3.70; $p < 0.00$), respectively. Students spending 2 h or more on SM had increased odds of self-reporting BII regardless of sex differences (Figure 3). Males were over two times as likely to use Reddit as compared to females (10% of the users were male vs. 3.8% of the users who were female). Although Reddit showed a statistically significant contribution to self-reporting BII (OR = 2.85; $p < 0.001$), the CI was large at 2.19–3.70, which may be attributed to most participants not using Reddit; regardless, those who do use the platform exhibit self-reporting BII. Data show that Reddit's contribution to BII is significant but may not be meaningful due to the low percentage of users in the study population.

Discussion

A tremendous gap in the literature exists in studying populations of the highest index of social vulnerability and health disparities regarding SM use and BII. There is a robust database of literature on other populations, including Latinx, Chinese, British, Australian, young adult, and university populations. This is the only study to date that has assessed

Number of Social Media Apps Used by Body Image Issues

FIGURE 1

Distribution of the number of reported social media (SM) platforms used by respondents' report of experiencing body image issues (BII).

Time on Social Media by Presence of Body Image Issues

FIGURE 2

Increase in daily time spent on social media (SM) platforms has a dose-response relationship to increasing self-reported body image issues (BII).

children, majority Americans of African descent, of the highest percentile of social vulnerability across an entire parish (47–50). No previous studies have looked at impoverished adolescents with a sample size of such magnitude; others of similar size focus on 18 years and older or neglect to account for social minority populations (50, 52–54). The current study examined whether self-reported BII was associated with SM use among 5,070 high school adolescents in Northwest Louisiana.

Social media platform usage: Male vs. females

One of the strongest drivers of BII is the reception of appearance-related feedback on SM (56). Although both males and females may be negatively impacted by SM, Manago et al., argues that females may receive a disproportionate amount of peer appearance-related feedback than males, with their data

TABLE 4 Odds ratios for self-reporting body image issues (BII) stratified by sex for highly visual social media (HVSM).

Predictors	OR	95% CI	P
Females			
Instagram	1.05	0.80 to 1.36	0.730
Pinterest	1.66	1.38 to 1.99	<0.001
YouTube	1.61	1.31 to 1.99	<0.001
Snapchat	1.30	1.06 to 1.59	<0.05
TikTok	1.65	1.38 to 1.97	<0.001
Males			
Instagram	0.88	0.61 to 1.27	0.510
Pinterest	3.31	2.05 to 5.36	< 0.001
YouTube	1.51	1.03 to 2.21	0.033
Snapchat	1.31	0.96 to 1.78	0.09
TikTok	1.50	1.11 to 2.03	<0.01

revealing females are evaluated more strongly on SM than males regarding their appearances (57). Following this, most research available to date has thoroughly explored the relationship between SM and the development of BII in females, with the studies that did look at both males and females emphasizing the latter. This includes a large body of literature dedicated to eating disorders (58–64). McCabe and Ricciardelli, have demonstrated overlap between the factors that affect both females and males in the development of BII, highlighting the importance of SM and BII studies that sample both females and males (65).

In contrast with many previous studies, our study sampled both females and males. Findings echo previous data in the disproportionate disparities of BII faced by females as compared to males with 77.6% females vs. nearly 20% of males reporting BII. Despite these similarities, researchers highlight a vulnerable population that, alongside similar BII, faces tremendous health disparities significantly higher than national averages. The public health crisis in Louisiana arguably leaves a wider gap in the equitable care necessary to rehabilitate the vulnerable adolescent population from BII and associated mental health disparities. Caddo Parish is one of the poorest parishes in Louisiana in a state that ranks 49th out of 50 in mental healthcare and mental health outcomes (34, 40).

Specific social media platforms related to body image issues

A large percentage of existing data on SM and body image reports findings in terms of Facebook usage, given its nearly three billion users (42, 61, 66–68). Previous studies have included SM variables of Facebook, Pinterest, Reddit, TikTok, and YouTube in conglomerate with results expressed in total SM usage and time (69). Other studies have collected robust data on the influence of solely Instagram and Snapchat contributing to BII in both males and females (70–72). In comparison, our

data presents novel findings across many different SM platforms (Instagram, Facebook, Snapchat, TikTok, Pinterest, YouTube, Reddit, and Twitter) by exploring the relationship of BII and SM through assessment of specific SM platforms used by males vs. females and their individual influences on BII. Findings indicated that females were more likely to use Pinterest, TikTok, Instagram, Snapchat, and Twitter; males were more likely to use Reddit. These findings are supported by past research showing females more likely to use SM as compared to males (17, 42, 64). Pinterest was the platform most highly associated with BII in Caddo respondents with usage for two or more hours a day resulting in 2.66 greater odds of developing BII.

Of note, Reddit revealed significantly higher odds of association with BII than other platforms. Reddit is a diverse platform that can both contribute to negative perception of self as well as operate as an outlet for individuals facing BII to commiserate and collectively soothe pain (73). Many sources reveal Reddit may offer a support community for various struggles from eating disorders to image-based dissatisfaction, while also at times endorsing and empowering negative self-perception, eating disorders, and BII (74–76). During times of isolation during the COVID-19 pandemic, Reddit has been shown as a space for reprieve from loneliness (77). These data reveal Reddit has potential to be both beneficial and harmful regarding BII (78). From our data, it is unclear if Reddit use is contributing to BII, or if Reddit is merely a coping outlet for those already experiencing BII; therefore, we cannot make assumptions on the direction of causality between Reddit and BII. This was an unexpected finding and should be investigated in future research.

While the use of HVSM was more likely to result in reports of BII, our data was unable to make an association between HVSM and increased BII. A diversity of SM platforms (both HVSM and non-HVSM) were associated with a statistically significant increase in BII among participants. Our results highlight a frightening reality of mental disease and BII for the majority of adolescents who use SM in this community; a community comprised of a majority of Americans of African descent, a population who, along with adolescents of Hispanic/Latinx descent, have been shown to use up to 2 h more screen time daily as compared to their European-descended counterparts (15).

Time on platforms related to development of body image issues

Previous data has shown adolescents of African descent and socioeconomically vulnerable populations average up to 36% more SM use and screen time than adolescents of European descent and higher income families (15). Looking at the adolescent community of Caddo Parish, a community comprised of majority Americans of African descent, data
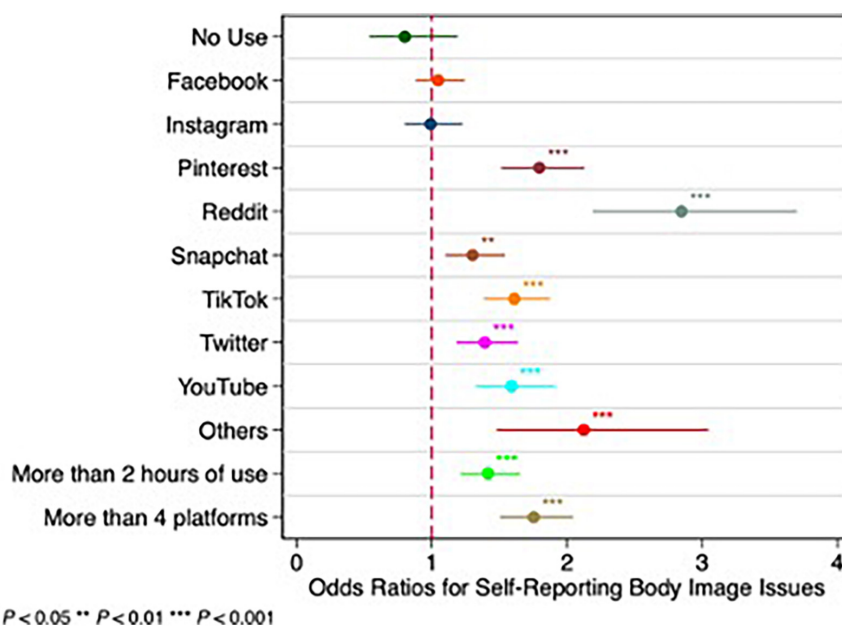
FIGURE 3
Odds ratios for self-reporting body image issues (BII) after adjusting for sex.

revealed over 60% of participants experiencing BII spent in excess of two or more hours a day on SM. This finding echoes that of numerous other sources who show similarly that time is positively associated with development of and persistence of BII (62, 79–81). Vandenbosch and Eggermont, found a positive correlation between frequency of checking SM accounts and increased body surveillance (81). de Vries et al., further found that the frequency of checking Facebook translated to increased investment in adolescent appearance (82). This dose-response relationship is also validated by several studies that found body dissatisfaction increases with total time spent on SM (83, 84).

Contrary to our hypothesis, data showed both females and males to self-report BII in the setting of increased time using SM; this is concordant with previous studies. A dose-response relationship between SM use and BII indicates BII and associated mental health issues transcend culture and social vulnerability (85, 86). Despite this, data emphasizes that outcomes have tremendous potential for variability given that vulnerable populations may not have the resources to mitigate the deleterious effects of negative self-perception and BII that other, non-impoverished communities may have access to.

Quantity of platforms related to body image issues

Several studies exist that focus solely on the SM platforms of Instagram, Facebook, or the combination; most data reported SM use generally associated with development of BII (11, 22, 26,

42, 61). Further, most data expressed outcomes in terms of SM use and BII but fail to individuate the discrete platforms' effect on BII (80, 87, 88). Our data revealed statistically significant associations between SM use and BII for seven of eight distinct platforms sampled: Facebook, Pinterest, Reddit, Snapchat, TikTok, Twitter, and YouTube; no statistically significant values for Instagram were shown to be associated with development of BII. Our findings emphasize that a diversity of mediums and content seem to broadly have negative impacts on body image.

Results further indicated concomitant use of three to four SM platforms to correlate with the highest burden of BII suffered. This is thought to be due, at least in part, to the low number of respondents who selected more or fewer platforms on the survey. Other studies have shown a positive correlation between increasing SM platform usage and the development of BII thoughts and habits, such as disordered eating (61, 89).

Findings in this impoverished adolescent population parallel that of other studies, showing that the association of SM and BII have a broadly bad effect on adolescent wellbeing. Regardless, these similarities are not determinant of long-term outcomes. The tremendous health disparities faced by these vulnerable communities has potential to impede recovery and perpetuate deleterious mental health insults, such as BII.

Potential limitations

There are limitations associated with the present study. Data were collected from a self-reported survey using a non-validated

survey instrument; the questions were written by a team of dedicated adolescent peers and then edited by Step Forward team members. This study also neglected to assess race as a determinant of BII and general health; these design elements and measures will be included in future studies. This study only sampled a single population and may be cause for non-generalizability of results when applying to broader populations outside of Northwest Louisiana. This study also did not utilize formal tools for measuring SM usage; an objective form of measuring SM activity and engagement may be beneficial for future studies. Finally, this study was conducted prior to the COVID-19 outbreak, so results may not accurately reflect the current mental landscape of Northwest Louisiana youth. It is a concern that adolescent BII and self-perception may be worse than depicted (90–92). Despite the limitations in the study design, we believe the study maintains clinical significance by clearly presenting the cogent relationship between SM usage and BII in a population devastated by health disparities and social vulnerability; the abundance of literature cited links BII to concurrent or later development of conditions that include, but are not limited to, eating disorders, suicidality, and general mental health disturbances such as anxiety and depression. We also recognize that the classification of BII and criteria for inclusion of this as a variable may be perceived as vague in the study design. The instrument designers felt it important to provide respondents with terms that were familiar with or would readily understand when answering the survey. With this in mind, more generalizable terms such as "issues with body image" were employed. This phrase was used to capture the landscape of adolescent BII more broadly and to "rule in" respondents who may be affected rather than create more narrow, specific criteria that have the potential to "rule out" due to respondent incomprehension or non-identification with an unfamiliar language. Regardless of whether these terms meet specific clinical definitions, we believe the consistent use of student self-reporting throughout the survey provides sufficient indication of student perceived harm for us to warrant study.

Future directions

Adolescent mental health disorders represent a serious problem and a significant burden of disease to the population. As adolescents increasingly spend more time on SM, such as they have since the COVID pandemic, the risk of related harms, such as BII, may increase as well.

This study produced valuable data on particularly vulnerable populations that may prove relevant and useful in highlighting BII and mental health challenges among those who face extreme health disparities and social vulnerability. Our data echoes current literature in that SM use is associated with significant BII in adolescents. However, no other study has assessed a population wherein the preponderance of children across an

entire parish that is majority Americans of African descent or that ranks in the highest percentile for social vulnerability (47–50). The consistency of our data with previous findings demonstrates the relationship between SM use and BII to transcend that of culture and socioeconomic status and be broadly deleterious for the adolescent population, a finding that would not be otherwise known until now. The current public health crisis in Louisiana highlights a gap in equitable care for these populations, a gap that may selectively impede recovery from BII and associated mental health disparities. Given the plasticity and sensitivity of the adolescent brain, inaction during this mental health crisis may have devastating effects on the lives of countless of adolescents (93).

Our research stresses the importance of understanding the factors affecting the health and wellbeing of this vulnerable adolescent community. Obtaining data from the lived experiences of adolescents may help researchers better understand and address these mental health crises. Furthermore, we believe direct partnership with the adolescent community may be essential for development of future supportive interventions. Findings may correspondingly suggest that platform providers prioritize development of tools to reduce harmful body image content available to vulnerable adolescents to mitigate the damaging effects of BII on adolescent present and future wellbeing.

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 Institutional Review Board and LSU Health Shreveport. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

CS: conceptualization, roles/writing—original draft, writing—review and editing, and submission. JM: data curation, conceptualization, roles/writing—original draft, and writing—review and editing. JT and RL: conceptualization, data curation, investigation, methodology, and writing—review and editing. TM: conceptualization and writing—review and editing. VA-Q and MB: formal analysis and writing—review and editing. PM and LA: data curation and writing—review and editing. JP: conceptualization, project administration,

and writing—review and editing. KM: data curation, investigation, project administration, supervision, and writing—review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

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