



The effect of social network strain on suicidal ideation among middle-aged adults with adverse childhood experiences in the US: A twelve-year nationwide study

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ARTICLE INFO

Keywords:

Social networks
Suicidal ideation
Adverse childhood experiences
Instrumental variables
Mid-life

ABSTRACT

Objective: Building on literature that measured the association between social network strain (SNS) and suicidal ideation using conventional regression analyses, we examined the effect of SNS, due to adverse childhood experiences (ACEs), on suicidal ideation using instrumental variables (IV) to eliminate the potential biases that may have occurred in earlier studies due to residual confounding.

Methods: This retrospective cohort study linked longitudinal data from the National Survey of Midlife Development in the United States (MIDUS) Refresher Biomarker Project (2012–2016), the MIDUS Refresher Project (2011–2014), the MIDUS 2 Biomarker Project (2004–2009), and the MIDUS 2 Project (2004–2006). Participants completed a phone interview, self-administered survey, and biomarker data collection. Exposure indicators included self-reported suicidal ideation, ACEs, and SNS from family, spouse, and friends. IV analysis was used to evaluate the continuous local average treatment effect of SNS on suicidal ideation when SNS only varied due to variation in ACEs.

Results: Our sample included 1703 middle-aged adults (52.9% females), which were followed up for 12 years. An IV probit model controlling for sociodemographic characteristics found a one-standard-deviation reduction in SNS reduced suicidal ideation by 22.6% ($p < 0.01$). A comprehensively controlled IV probit model found that a one-standard-deviation reduction in SNS is associated with a 21.4% ($p = 0.05$) decrease in suicidal ideation.

Conclusions: The causal pathway from SNS (due to ACEs) to suicidal ideation among middle-aged adults was established using IV analysis in this large-scale longitudinal study. The magnitude of this effect is sufficient to warrant the development of programs to improve social network relationships among family, friends, and spouses/partners. Suicide prevention programs addressing SNS may significantly reduce suicidal ideation among middle-aged Americans who have experienced ACEs.

1. Introduction

Suicide is the second leading cause of death among individuals 10–34 years and the fourth among people ages 35–54 in the US (CDC, 2021). Suicidal ideation and attempts among midlife adults in US emergency departments (ED) increased by 21% from 2001 to 2020 (CDC, 2022). Suicidal ideation is a risk factor for later-life suicide attempts and suicide deaths (Baca-Garcia et al., 2011; McHugh et al., 2019; Rossom et al., 2017; Rubio et al., 2020). Around 60% of suicidal ideation transitions to suicide plans and attempts that occur within the first year of suicidal ideation onset (Nock et al., 2009). Effectively

identifying and treating individuals with suicidal ideation is key to preventing both suicide attempts and suicide deaths (Czeisler et al., 2021; Walsh et al., 2021).

The complex nature of suicidal ideation, however, creates challenges in making causal inferences regarding prediction, primarily due to uncontrolled confounding that can result in parameter bias (Belsher et al., 2019; García de la Garza et al., 2021; Walsh et al., 2021). Additionally, most previous studies used cross-sectional designs, where reverse causation often cannot be ruled out because suicidal behaviors may occur before, and increase the levels of many risk factors (Brent et al., 2019; Gould et al., 2005). Therefore, most risk factors of suicide

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<https://doi.org/10.1016/j.ssmph.2022.101120>

Received 27 January 2022; Received in revised form 3 May 2022; Accepted 6 May 2022

Available online 20 May 2022

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reported in the previous literature, while valuable, are either associations or have a narrow context within which causal interpretation is possible based on a meta-analysis (Franklin et al., 2017).

Causality is essential to determine whether interventions targeting modifiable factors can reduce suicidal ideation and subsequent fatal suicidal behaviors (Franklin et al., 2017). We present the first study determining the causal effect of social network strain on suicidal ideation. We focus on SNS because existing studies highlighted the importance of identifying risks beyond major psychiatric disorders (Mann et al., 2005; Xiao & Lindsey, 2021a), and SNS is a highly modifiable factor.

1.1. Social network strains and suicidal ideation

Social network strain (SNS) is defined as negative perceptions and experiences arising from social network interactions (Walen & Lachman, 2000), including too many demands, criticisms, disappointments, and irritations from interactions with family members, friends, and spouses/partners. Theoretically, Durkheim (1952, 2005) suggested suicide deaths are a result of social conflicts in social integration and moral regulation. In particular, a lack of social integration can increase social disconnection and suicide risk. Joiner's (2005) Interpersonal Theory of Suicide (IPTS) further states that thwarted belongingness and perceived burdensomeness can introduce suicidal ideation through hopelessness (Van Orden et al., 2010). For example, interpersonal hopelessness was found to predict suicidal ideation over time (Rogers & Joiner, 2019; Tucker et al., 2018). The three-step theory (3ST) of suicide by Klonsky and May (2015) formulates suicidal ideation as resulting from the combination of psychological pain and hopelessness, where positive social networks are protective factors against escalating suicidal ideation. Both IPTS and 3ST are supported by interpersonal and psychological correlates of suicide (Klonsky et al., 2021).

More recently, the strain theory of suicide (STS) posits that suicide is usually preceded by psychological strain (Zhang et al., 2011). Strains are defined as pressures or stresses that pull the individual in different directions and/or the lack of coping ability in a crisis. STS suggests at least four sources of strain: differential values, reality versus aspiration, relative deprivation, and deficient coping.

SNS from the demands, criticisms, disappointments, and irritations of family, friends, and partners/spouses can indicate a lack of social integration, thwarted belongingness, and/or perceived burdensomeness, psychological pain and hopelessness, and/or any of the four types of strains listed above (Zhang et al., 2011). These robust theoretical reasons support the contention that people with more SNS are more likely to exhibit suicidal ideation.

Empirically, numerous studies have examined the associations between SNS and suicidal ideation. Lew et al. (2020) recently found that SNS, resulting from conflicting and competing pressures in an individual's life, are associated with greater risks of suicidal ideation. Positive associations between strains and suicide have also been identified in people who have attempted suicide (Sun & Zhang, 2016), including young people and celebrities (Zhang et al., 2013). These studies offer a strong rationale for testing whether SNS may be part of the causal pathway leading to suicidal ideation and thus a key intervention target in preventing suicidal ideation (Chang et al., 2017; Morina et al., 2021; National Academies of Sciences, 2020). To date, however, this causal relationship has not been established.

1.2. Adverse childhood experiences and suicidal ideation

Adverse childhood experiences (ACEs) include all types of abuse and neglect (e.g., emotional abuse, sexual abuse, physical abuse, emotional neglect, physical neglect) as well as exposure to household challenges (e.g., parental divorce, parental depression, alcohol or drug abuse of any parent) experienced by children under 18 (Merrick et al., 2018). An estimated 62% of adults surveyed across 23 states in the US reported

having at least one ACE, and nearly one-quarter reported having three or more ACEs (Merrick et al., 2018).

ACEs exhibit a dose-response relationship with physical and mental health problems in adulthood, including suicidal ideation, suicide attempts, and suicide deaths (Pournaghash-Tehrani et al., 2021; Thompson et al., 2019). An accumulation of ACEs was associated with 1.4 odds of suicide ideation and 2.7 odds of suicide attempts (Thompson et al., 2019). However, ACEs may not be associated with suicidal ideation directly (Mann, 2003; Sachs-Ericsson, Rushing, Stanley, & Sheffler, 2016). There is evidence that strengthening social networks may prevent suicidal behaviors. High levels of support from teachers and friends offset the impact of familial adversity for non-suicidal self-injury and suicidal behaviors among 9th-graders (Forster et al., 2020). Recent studies have shown that ACEs may increase the risks of suicidal ideation through their negative effects on interpersonal social network relationships (Johnson et al., 2002; Polanco-Roman et al., 2021). While none of these important studies estimated causal relationships, they are sufficient to hypothesize that SNS may cause suicidal ideation and are likely to vary by each individual's level of ACEs.

Addressing whether the tendency of SNS to cause suicidal ideation increases as ACEs increase is a critical, but debatable question. It is critical because SNS is modifiable whether or not ACEs are present, offering a promising target for suicide prevention. On the other hand, it is necessarily debatable as causal impacts are difficult to demonstrate.

1.3. Current study: solving methodological challenges and the potential of an instrumental variable approach

Instrumental variable (IV) models, long used in health economics to draw causal inferences when using observational data, are increasingly being applied to ascertain causal relationships in medical and psychiatric research (Desai et al., 2018; Maciejewski & Brookhart, 2019; Ohlsson & Kendler, 2020). Since the selected instrument serves as a proxy for a randomization process, this approach offers the opportunity to correct parameter bias arising due to endogeneity: confounding, reverse causation, and random measurement error (Kim et al., 2011; Ohlsson & Kendler, 2020).

The current study focuses on the causal effect of SNS on the probability of suicidal ideation, using ACEs as the exogenous instrument in an IV model (Fig. 1). The key assumptions are that ACEs are exogenous, strongly and monotonically correlated with SNS, and only affect suicidal ideation through SNS, conditional on all other pathways between ACEs and suicidal ideation being accounted for via the inclusion of appropriate covariates (Kalmakis & Chandler, 2015). By isolating the variations in SNS to those due to ACEs (using ACEs as an IV) can overcome endogeneity bias and yield valid effect estimates (Wooldridge, 2015a; 2015b).

Our study design is further strengthened by the time ordering of our longitudinal data following middle-aged adults nationwide for over twelve years (Fig. 1). ACEs necessarily occurred prior to assessing participants' SNS (in midlife), and SNS was assessed before suicidal ideation outcomes (during follow-up surveys). Since ACEs necessarily occur before adulthood, they are exogenous (their cause is external to the model). Other things equal, ACEs affect SNS, which affects suicidal ideation. To our knowledge, this is the first study to apply IV analysis to estimate the causal effect of SNS on suicidal ideation and to provide an unbiased estimate of this population-level health benefit among midlife adults.

2. Material and methods

2.1. Data and participants

We compiled a longitudinal dataset from four samples of the National Survey of Midlife Development in the United States (MIDUS) study (Brim et al., 2019), a longitudinal investigation of health among

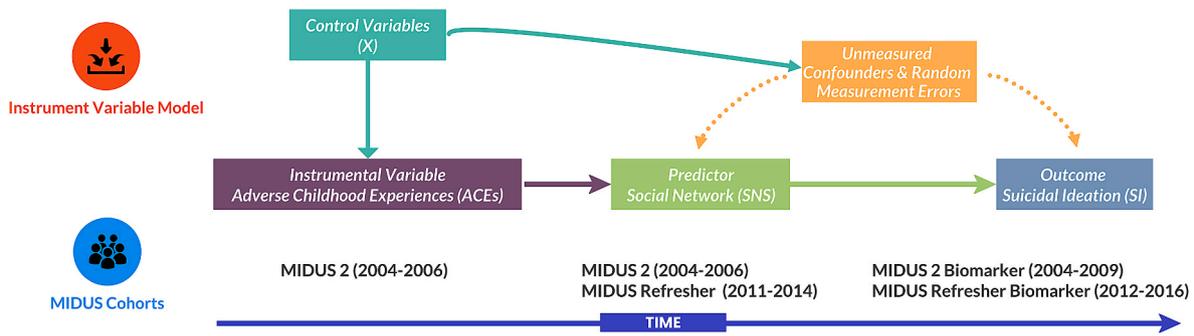


Fig. 1. Conceptual Model for Causal Mediation Analysis in Instrumental-Variable Regressions

The relationship between social networks strains (SNS) and suicidal ideation (SI), can be estimated using our instrument variable (ACEs), that are valid conditional on included covariates, X (see 2.2.4). All variables in X are included to close off backdoor paths (non-causal paths) between SNS and SI, or in econometric terms, to remove any correlation between the set of instruments and the error term.

middle-aged adults (See Fig. 2). The first wave of the MIDUS study collected survey data from a total of 7108 participants aged 25 and 74 years old through a national RDD (random digit dialing) primarily in 1995/96. The first sample was drawn from the MIDUS 2 Project (2004–2006), which contains a 10-year follow-up sample of participants (aged 35–86) from the original MIDUS 1 baseline cohort using phone interviews, self-administered questionnaires via mail, and a separate sample of African American participants from Milwaukee (Ryff et al., 2010). The second sample consisted of the MIDUS 2 Biomarker Project (2004–2009), a longitudinal follow-up subsample of MIDUS 2, which contains biological assessments to facilitate the identification of biopsychosocial pathways that contribute to diverse health outcomes (Ryff et al., 2010). The third sample contains participants aged 25–74 from the MIDUS Refresher Study (2011–2014), designed to replenish the original MIDUS 1 baseline cohort and collect the same comprehensive assessments (Ryff et al., 2016). Data were collected through a 30-min phone interview followed by two 50-page mailed self-administered questionnaires. The last sample was from the MIDUS Refresher Biomarker study (2012–2016), which paralleled the purpose and design of the MIDUS 2 Biomarker Project (Love et al., 2010). Subjects were recruited through a two-step process: mailed recruitment packet and phone call to schedule a Clinical Research Units (CRU) visit. Informed consent was obtained from all participants (Desai et al., 2018).

The response rates of the questionnaires for the four samples were 81.0%, 39.3%, 73.0%, and 41.5%, respectively. While the lower response rates in follow-up samples may impact external validity, they do not impact internal validity as selection bias is controlled for using an IV. Following previous research (Boylan et al., 2020; Yip et al., 2021), the current study combined these four samples. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines for cohort studies. This study was not required to obtain ethics approval since it uses publicly-available data that contain no identifiable private information. Therefore, it is not considered human subjects research by the Committee for the Protection of Human Subjects at the University of California, as defined by federal regulations at 45 CFR 46.102 (DHHS) and/or 21 CFR 50.3 (FDA).

2.2. Measures

2.2.1. Outcome variable: suicidal ideation

Suicidal ideation was measured with one five-point question in the Mood and Anxiety Symptoms Questionnaire (MASQ) in the MIDUS 2 Biomarker (2004–2009) and Refresher Biomarker (2012–2016) projects (Watson et al., 1995): “During the past week, how much you have felt or experienced thoughts about death or suicide?” A binary variable was created to indicate past-week suicidal ideation (having “a little bit” up to “extreme” thoughts of suicide) vs. non-suicidal ideation cases (having “no” thoughts of suicide). Single-question measures of suicidal ideation have been widely used in previous research (e.g., the Patient Health Questionnaire) (Kroenke et al., 2001) and have demonstrated good validity in clinical assessment (Walker et al., 2010).

2.2.2. Predictor variable: social networks strain

SNS was a score calculated from the mean of the values across the 12 items (eTable 1) of the SNS measure. Subjects were asked four questions of each of the three network groups (family, friends, spouse) concerning the frequency of 1) being criticized, 2) receiving too many demands, 3) someone in the relevant group getting on one’s nerves, and 4) being let down. Each variable ranges from 4 “Often” to 1 “Never.” For individuals without a spouse/partner, we treated their spouse-level SNS as zero. The fact that SNS was measured during the MIDUS 2 (2004–2006) and MIDUS Refresher (2011–2014) projects (prior to suicidal ideation outcomes) eliminated the possibility of reverse causation (Lee et al., 2019). Family strain, spousal strain, and friend strain have been validated and have demonstrated good reliability (Grzywacz & Marks, 1999; Schuster et al., 1990; Walen & Lachman, 2000).

2.2.3. Instrumental variable: ACEs

Exposure to ACEs was constructed using a summed score of eight types of adverse experiences (emotional abuse, sexual abuse, physical abuse, emotional neglect, physical neglect, parental divorce, parental depression, alcohol or drug abuse of any parent) before age 18 (yes/no). This is consistent with previous theories (Felitti et al., 1998) and

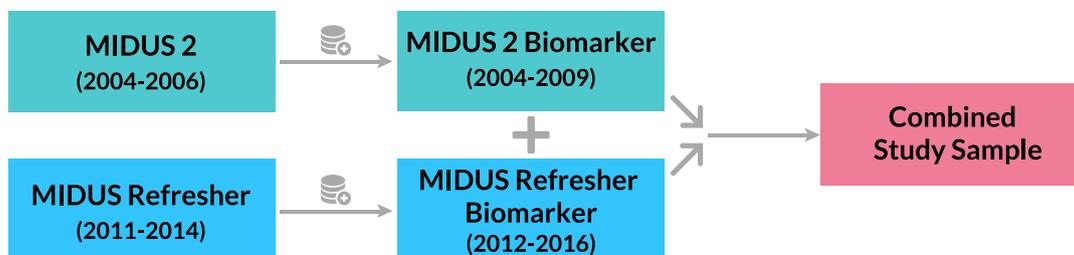


Fig. 2. Construction of study sample.

empirical applications (Hostinar et al., 2015).

2.2.4. Covariates

We include a comprehensive list of covariates known to influence the association between SNS and suicidal ideation and the association between ACEs and suicidal ideation based on previous literature (Franklin et al., 2017; Kalmakis & Chandler, 2015), which can be grouped into five categories: physical health conditions, psychological conditions, developmental disruption and sequelae, health risk behaviors, and healthcare utilization. (1) *Physical health conditions* include headache frequency in the last 30 days, sleep quality (Pittsburgh Sleep Quality Index), body mass index, autoimmune disease status (ever), number of chronic conditions, diminished health status (poor health or fair health), and five inflammatory markers (Hostinar et al., 2015; Wang et al., 2014), including C-reactive protein, interleukin-6, fibrinogen, E-selectin, and intercellular adhesion molecule. (2) *Psychological conditions* include self-esteem, positive affect, depression, anxiety, psychological distress (Brown et al., 2020) using the Kessler K6 Psychological Distress Scale (Kessler et al., 2002), and Big Five personality traits (openness, agreeableness, extraversion, neuroticism, conscientiousness). The latter two personality traits, neuroticism and conscientiousness, are related to emotional stability and impulsiveness, known determinants of suicidal ideation and suicide attempts (Cobb-Clark & Schurer, 2012). We also included a measure of stress reaction (Multidimensional Personality Questionnaire). (3) *Developmental disruption sequelae* included experiences of homelessness (since the previous survey) and being jailed (ever). (4) *Health risk behaviors* included were current smoking status, binge drinking (measured as the number of days with more than five drinks per day during the past 30 days), substance use (ever used the following in the past 12 months either without a doctor's prescription, in larger amounts than prescribed, or for a longer period than prescribed: sedatives, tranquilizers, stimulants, painkillers, antidepressants, inhalants, marijuana/hashish, cocaine/crack, LSD/hallucinogens, heroin). (5) *Healthcare utilization* included visits for mental health treatment and visits to physicians.

We also included sociodemographic and survey controls. These include age, sex, race/ethnicity, marital status, educational level, household income, health insurance status, and a MIDUS cohort indicator (MIDUS 2 or MIDUS Refresher).

2.3. Statistical analysis

We estimate an IV model to determine the continuous local average treatment effect (LATE) of SNS in increasing suicidal ideation where SNS only varies due to variation in ACEs. Because the mean of suicidal ideation is 0.126 and thus does not fall within the standard [0.2, 0.8] range, in which linear probability models typically yield virtually identical results to nonlinear models such as logit or probit (Cox, 1972), we estimate IV probit models (Wooldridge, 2015b). For our IV probit model to be valid, four conditions must be satisfied. First, our instrument must be exogenous (its value cannot vary due to any other variable in the model). ACEs are necessarily exogenous in our model as ACEs occur in childhood. Second, the instrument must be strongly correlated with SNS, our endogenous variable of interest. We use weak instrument tests to empirically evaluate whether the correlation between the instrument and the endogenous variable is sufficiently strong (Pflueger and Wang, 2015). Third, ACEs can only affect suicidal ideation through their effect on SNS. In other words, ACEs must be independent of the outcome, conditional on included covariates. We have listed relevant covariates above based on previous systematic reviews (Franklin et al., 2017; Kalmakis & Chandler, 2015). Finally, ACEs must have a monotonic relationship with SNS, meaning that more (less) ACEs cause more (less) SNS or no change (no 'defiers'). We reasonably assume this condition is satisfied.

We perform weak instrument tests using two-stage least squares (2SLS) models as such tests are not possible using IV probit. These tests

only involve the first-stage of 2SLS, so the fact that suicidal ideation does not fall within the [0.2, 0.8] interval is inconsequential.

Finally, we perform sensitivity analyses by reporting IV probit models that only include sociodemographic controls, in addition to the fully controlled models. We also calculated the variance inflation factor (VIF) for each set of controlled variables to determine whether multicollinearity may be an issue. All models also corrected for heteroscedastic standard errors. Statistical analyses are conducted in Stata 16.

3. Results

3.1. Descriptive statistics

Table 1 reports means (means are equivalent to proportions for binary variables) including standard deviations for nonbinary variables. We included two samples: a sample only containing sociodemographic controls (N = 1703) and a sample that contains the full set of controls (N = 1162).

3.2. Instrumental variable model results

Our IV probit estimates, which are presented as average marginal effects, showed a one-standard-deviation decrease in SNS is associated with a 21.4% ($p = 0.05$) decrease in suicidal ideation when using the fully controlled model (Table 2), while the model only using sociodemographic controls showed a 22.6% ($p < 0.01$) decrease (Table 3). In each case, a Wald test of exogeneity rejects the hypothesis that SNS is exogenous. The average marginal effects of SNS in our IV probit models are shown side by side with the average marginal effects from standard probit models that do not correct the endogeneity of SNS. In these models, the average marginal effects of a one-standard-deviation decrease in SNS are 1.3% ($p = 0.30$) and 4.2% ($p < 0.01$) decreases in suicidal ideation for the fully controlled and sociodemographic controls only models, respectively. Thus, a large amount of bias is present in the standard probit model. A weak instrument test yielded Kleibergen-Paap rk Wald F statistics of 16.97 and 82.72 for the fully-controlled IV model and IV model only including sociodemographic controls, respectively, both of which are greater than the critical value of 16.38 for 10% maximal IV size. This indicates that the instrument is sufficiently strong (Stock & Yogo, 2005).

The mean VIF of the set of variables included in the fully controlled and sociodemographic-controlled-only models were 2.09 and 2.65, respectively. Only education variables had a VIF greater than 3.10, indicating no issues with multicollinearity among the extensive additional controls included in the fully controlled model.

Additional results for the IV probit models must be interpreted with caution, as IV models only correct the parameter bias for the endogenous variable of interest (SNS in the current case). Therefore, only the coefficients of this variable have a causal interpretation. Of note, covariates in IV models are only included to meet the criteria of IV models, i.e., that the instrument is not correlated with the error terms conditional on included covariates. Thus, the coefficients of these covariates have no meaningful causal interpretations to explain the variations in suicidal ideation outcomes.

Regarding the sociodemographic covariates, in the fully controlled model, age > 44 is positively correlated, and being married has a negative association with suicidal ideation ($p < 0.05$). Sex, race/ethnicity, education, family income, and health insurance status have no significant association with suicidal ideation. The alternative model (only controlling for sociodemographic characteristics) showed similar results (see Tables 2 and 3).

With regard to physical health covariates, lower sleep quality was associated with increased risks of suicidal ideation ($p < 0.05$). Having headaches, body mass index, autoimmune disease status, chronic conditions, diminished health status (poor health or fair health), and inflammatory markers have no significant association with suicidal

Table 1
Characteristics of the participants included in the study sample.^a

Characteristics	Sociodemographic Controls Only		Fully Controlled Set	
	(N = 1703)		N = 1162)	
	Mean	SD	Mean	SD
Suicidal Ideation (binary)	0.127	–	0.126	–
Social Network Strain (range 1–4)	1.792	0.483	1.780	0.475
ACEs (8-item) (range 0–8)	3.530	1.878	3.541	1.876
<i>Sociodemographic Characteristics</i>				
<i>Age</i>				
Ages 45-54	0.268	–	0.247	–
Ages 55-64	0.244	–	0.242	–
Ages 65+	0.216	–	0.227	–
<i>Sex</i>				
Female	0.529	–	0.518	–
<i>Race/ethnicity</i>				
Black	0.045	–	0.041	–
Hispanic	0.041	–	0.035	–
Asian/Pacific Islander	0.009	–	0.009	–
Other Race	0.063	–	0.061	–
<i>Marital Status</i>				
Married	0.689	–	0.702	–
Separated	0.016	–	0.015	–
Divorced	0.134	–	0.125	–
Widowed	0.048	–	0.045	–
<i>Education</i>				
High School/GED	0.169	–	0.156	–
Some College	0.291	–	0.277	–
Bachelors	0.246	–	0.249	–
Graduate School	0.267	–	0.293	–
Household Income (\$100,000s)	8.319	6.640	8.465	6.571
Health Insurance (binary)	0.929	–	0.935	–
<i>Physical Health conditions</i>				
Poor-to-fair Health Status (binary)	–	–	0.103	–
Headache Frequency (past 30 days)	–	–	0.044	0.205
Body Mass Index	–	–	28.332	6.063
Autoimmune Disorder (ever) (binary)	–	–	0.012	–
C-reactive protein, (ug/ml)	–	–	2.683	4.786
Fibrinogen, (mg/dl)	–	–	336.910	75.493
Interleukin-6, (pg/ml)	–	–	1.227	4.713
E-Selectin, (ng/ml)	–	–	40.222	19.701
Intercellular adhesion molecule-1, (ng/ml)	–	–	277.750	156.550
Sleep Quality (PSQI) (range 0–19)	–	–	5.603	3.214
Chronic Conditions (No.)	–	–	2.338	2.404
<i>Psychological conditions</i>				
Anxiety (binary)	–	–	0.025	–
Depression (binary)	–	–	0.100	–
Moderate-to-Severe Psychological Distress (binary)	–	–	0.279	–
Positive Affect (range 1–5)	–	–	3.434	0.719
Stress Reaction (MPQ) (range 3–12)	–	–	6.129	2.263
Self Esteem (range 11–49)	–	–	37.925	7.489
Big 5: Openness (range 1–4)	–	–	2.972	0.514
Big 5: Agreeableness (range 1–4)	–	–	3.372	0.529
Big 5: Extraversion (range 1–4)	–	–	3.092	0.591
Big 5: Neuroticism (range 1–4)	–	–	2.038	0.651
Big 5: Conscientiousness (range 1–4)	–	–	3.396	0.466
<i>Developmental disruption sequelae</i>				
Homeless (since last interview) (binary)	–	–	0.006	–
Jail Detention (ever) (binary)	–	–	1.941	–
<i>Health Risk Behaviors</i>				
Current Smoker (binary)	–	–	0.389	–
5+ Drinks (monthly frequency)	–	–	0.557	2.395
Substance Use (binary)	–	–	0.119	–
<i>Healthcare Utilization</i>				
Mental Health Visits (annual)	–	–	1.958	7.645
Physician Visits (annual)	–	–	3.499	3.915
MIDUS 2 Survey (binary)	0.586	–	0.489	–

Abbreviations. ACEs, Adverse Childhood Experiences; SD, Standard Deviation; PSQI (Pittsburgh Sleep Quality Index); MPQ (Multidimensional Personality

Questionnaire) ug, microgram; ml, milliliter; mg, milligram; dl, deciliter; pg, picogram; ng, nanogram; No., number.

^a Data were compiled from the MIDUS 2, MIDUS Refresher, MIDUS Refresher Biomarker Project, and MIDUS 2 Biomarker Project.

ideation (see Tables 2 and 3).

Psychological conditions, including self-esteem, positive affect, depression, anxiety, psychological distress, Big Five personality traits, and trait stress reaction have no significant association with suicidal ideation. Similarly, developmental disruption sequelae, including recent homelessness and ever being jailed have no significant association with suicidal ideation.

Health risk behaviors, including smoking status, binge drinking, and substance abuse have no significant association. Similarly, healthcare utilization, including visits for mental health treatment and visits to physicians, has no significant association with suicidal ideation.

A full set of results in which all variables are unstandardized (no z-scores are used) is available in the Appendix. This includes both the fully controlled (eTable 2) and sociodemographic control only models (eTable 3).

4. Discussion

To our knowledge, this is the first study to document the causal effect of SNS on suicidal ideation. In particular, we found that reducing SNS decreases suicidal ideation among people whose SNS has worsened due to ACEs. The results show an approximate one-fifth decrease in suicidal ideation from a one-standard-deviation reduction in SNS, a robust result even after adjusting for a full set of control variables identified from previous literature. Results suggest the need to carefully screen for SNS among at-risk individuals with ACEs. Notably, we provide rigorous evidence that focusing on reducing SNS and enhancing positive relationships among families, friends, and spouses is important in developing suicide prevention programs.

4.1. Social network strain

Our findings contribute to etiologic models and prevention efforts with evidence addressing the effect of SNS on suicidal ideation among patients with ACEs. In particular, our findings show that for high-risk individuals with ACEs, SNS is critical to their heightened risk of suicidal ideation. Suicidal interventions targeting reducing SNS with family, friends, and spouses have the potential to significantly reduce suicidal thoughts among middle-aged adults with high-level ACEs.

4.2. The role of adverse childhood experiences

Our findings, based on variation in ACEs, suggest that interventions to improve SNS may not need to involve all members of a subject's social network. Individuals experiencing ACEs in early life may be significantly susceptible to social strain and conflicts (Xiao & Lindsey, 2021a), perceiving them as more traumatic, hopeless, and stressful (Johnson et al., 2002; Lindsey & Xiao, 2019). Therefore, SNS will tend to cause suicidal ideation more often among people with ACEs, as they are neurobiologically more sensitive to relational demands, criticisms, frustrations, and irritation (Mann & Rizk, 2020; Xiao & Lindsey, 2021a).

The impaired cognitive control of mood and potential over-reaction to SNS could increase the risk of suicidal ideation. Interventions at the individual level to lessen this emotional sensitivity may thus be effective in reducing suicidal ideation. For example, the Cognitive Reappraisal Intervention for Suicide Prevention (CRISP) teaches middle-aged, and older hospitalized patients to manage emotional crises (e.g., relationship strains) by providing strategies for an adaptive response to these personalized triggers and negative emotions, which can reduce suicidal ideation and improve suicide prevention (Kiosses et al., 2018). Further research is needed to determine how similar interventions will be

Table 2
Effect of social network strain due to ACEs on suicidal ideation (full set of controls, N = 1162).

	IV Probit		Probit	
	Suicidal Ideation (binary)		Suicidal Ideation (binary)	
	Coefficient	Standard Error	Coefficient	Standard Error
Social Network Strain (z-score)	0.214*	0.109	0.013	0.012
Age				
Age <45 [Reference]				
Ages 45-54	0.092*	0.030	0.077*	0.026
Ages 55-64	0.062	0.039	0.019	0.028
Ages 65+	0.129*	0.048	0.067*	0.030
Sex				
Male [Reference]				
Female	-0.020*	0.030	0.014	0.021
Race/ethnicity				
White [Reference]				
Black	-0.015	0.046	-0.014	0.044
Hispanic	0.143	0.075	0.061	0.051
Asian/Pacific Islander	-0.017	0.133	0.011	0.102
Other Race	-0.037	0.052	0.005	0.042
Marital Status				
Single [Reference]				
Married	-0.261*	0.118	-0.053	0.033
Separated	-0.284	0.148	-0.069	0.073
Divorced	-0.062	0.042	-0.038	0.036
Widowed	0.004	0.059	-0.017	0.053
Education				
Less than High School [Reference]				
High School/GED	-0.032	0.060	-0.021	0.059
Some College	-0.052	0.059	-0.029	0.057
Bachelors	-0.040	0.063	0.0003	0.058
Graduate School	-0.030	0.061	-0.013	0.059
Household Income (\$100,000s)	-0.002	0.002	0.0002	0.001
Health Insurance				
Uninsured [Reference]				
Insured	0.019	0.044	0.015	0.039
MIDUS Waves				
MIDUS Refresher [Reference]				
MIDUS 2 Survey (binary)	-0.029	0.027	-0.001	0.019
Physical Health conditions				
Good-to-Excellent Health [Reference]				
Poor-to-fair Health Status (binary)	0.039	0.034	0.022	0.028
Headache Frequency (past 30 days)	0.026	0.057	0.005	0.043
Body Mass Index	0.00003	0.002	0.002	0.002
No Autoimmune Disorder [Reference]				
Autoimmune Disorder (ever) (binary)	0.007	0.068	0.018	0.071
C-reactive protein, (ug/ml)	0.016	0.016	0.002	0.010
Fibrinogen, (mg/dl)	0.015	0.014	0.006	0.011
Interleukin-6, (pg/ml)	-0.005	0.005	0.002	0.004
E-Selectin, (ng/ml)	-0.011	0.013	0.0004	0.010
Intercellular adhesion molecule-1, (ng/ml)	-0.006	0.010	-0.005	0.008
Sleep Quality (PSQI) (range 0-19)	0.008*	0.003	0.008*	0.003
Chronic Conditions (No.)	-0.004	0.005	-0.001	0.004
Psychological conditions				
No Anxiety [Reference]				
Anxiety (binary)	-0.068	0.072	-0.080	0.060
No Depression [Reference]				
Depression (binary)	0.043	0.035	0.057	0.030

Table 2 (continued)

	IV Probit		Probit	
	Suicidal Ideation (binary)		Suicidal Ideation (binary)	
	Coefficient	Standard Error	Coefficient	Standard Error
No Psychological Distress [Reference]				
Moderate-to-Severe Psychological Distress (binary)	0.044	0.029	0.027	0.025
Positive Affect (range 1-5)	-0.021	0.022	-0.035*	0.018
Stress Reaction (MPQ) (range 3-12)	0.005	0.007	0.009	0.006
Self Esteem (range 11-49)	0.022	0.021	-0.006	0.013
Big 5: Openness (range 1-4)	-0.002	0.016	0.018	0.011
Big 5: Agreeableness (range 1-4)	0.017	0.014	0.005	0.011
Big 5: Extraversion (range 1-4)	-0.019	0.014	-0.011	0.012
Big 5: Neuroticism (range 1-4)	-0.032	0.018	-0.012	0.013
Big 5: Conscientiousness (range 1-4)	0.01	0.013	-0.002	0.010
<i>Developmental disruption sequelae</i>				
No Homelessness [Reference]				
Homeless (since last interview) (binary)	0.049	0.134	-0.046	0.094
No Jail Detention [Reference]				
Jail Detention (ever) (binary)	-0.070	0.045	-0.091*	0.035
<i>Health Risk Behaviors</i>				
Nonsmoker [Reference]				
Current Smoker (binary)	-0.001	0.022	0.0004	0.020
5+ Drinks (monthly frequency)	-0.003	0.007	-0.001	0.005
No Substance Use [Reference]				
Substance Use (binary)	-0.018	0.034	0.005	0.028
<i>Healthcare Utilization</i>				
Mental Health Visits (annual)	0.0005	0.001	0.001	0.001
Physician Visits (annual)	-0.005	0.003	-0.005	0.003
Pseudo R ²			0.13	
Wald χ^2 Test of Exogeneity	4.99*		-	
Wald χ^2	235.04*		116.41*	

All coefficients are average marginal effects from probit models with standard errors computed using the delta method.

There is no constant in marginal effects probit models. Pseudo R² is not interpretable in an instrumental variables model and is omitted.

*: $p \leq 0.05$.

generalized to older adults.

4.3. Implications

Findings from this study hold important clinical and public health implications. Identifying individuals who experienced ACEs may be a promising screening tool for non-psychiatric physicians and community public health practitioners to better screen, diagnose, and treat depression, decreasing the risks of suicidal ideation and suicide death (Mann et al., 2021). Developing preventative approaches to reduce risks for ACEs is an important future direction to reduce suicidal ideation among middle-aged adults (Navarro et al., 2021).

Table 3
Effect of social network strain due to ACEs on suicidal ideation (sociodemographic controls only, N = 1703).

	IV Probit		Probit	
	Suicidal Ideation (binary)		Suicidal Ideation (binary)	
	Coefficient	Standard Error	Coefficient	Standard Error
Social Network Strain (z-score)	0.219*	0.046	0.042*	0.010
Age				
Age <45 [Reference]				
Ages 45-54	0.065*	0.024	0.051*	0.022
Ages 55-64	0.063*	0.028	0.016	0.024
Ages 65+	0.107*	0.034	0.031	0.026
Sex				
Male [Reference]				
Female	-0.022	0.018	-0.007	0.016
Race/ethnicity				
White [Reference]				
Black	0.015	0.038	0.018	0.036
Hispanic	0.108*	0.049	0.047	0.042
Asian/Pacific	0.056	0.109	0.003	0.088
Islander				
Other Race	-0.032	0.041	0.018	0.035
Marital Status				
Single [Reference]				
Married	-0.295*	0.051	-0.134*	0.027
Separated	-0.246*	0.086	-0.074	0.059
Divorced	-0.069*	0.032	-0.070*	0.031
Widowed	-0.005	0.048	-0.050	0.044
Education				
Less than High School [Reference]				
High School/GED	0.012	0.052	0.016	0.050
Some College	-0.014	0.05	-0.006	0.049
Bachelors	0.021	0.051	0.029	0.05
Graduate School	-0.010	0.052	-0.012	0.051
Household Income (\$100,000s)	-0.001	0.002	-0.00005	0.001
Health Insurance				
Uninsured [Reference]				
Insured	0.018	0.034	-0.013	0.030
MIDUS Waves				
MIDUS Refresher [Reference]				
MIDUS 2 Survey (binary)	-0.017	0.019	-0.002	0.017
Pseudo R ²	-		0.042	
Wald χ^2 Test of Exogeneity	20.83*		-	
Wald χ^2	132.05*		51.94*	

All coefficients are average marginal effects from probit models with standard errors computed using the delta method.

There is no constant in marginal effects probit models. Pseudo R² is not interpretable in an instrumental variables model and is omitted.

*: $p \leq 0.05$.

The substantial causal effect of SNS suggests the need for a new paradigm shift in clinical practice to effectively address suicidal behaviors in context, in that what matters are the lived experiences of patients – social networks. For middle-aged adults with ACEs, actively detecting social network demands, criticisms, irritations and frustrations may identify at-risk subpopulations with suicidal ideation and possible future suicide attempts (Mueller et al., 2021; Xiao & Lindsey, 2021a).

Our results may be particularly relevant to the recent increases in suicidal thoughts and behaviors among females and racial/ethnic minority populations. In particular, social networks across family, friends, and spouses are highly valued among Asian-American, Black, and Hispanic cultures (Xiao & Lindsey, 2021b). Suicidal ideation has also demonstrated an increasing trend among females and sexual minorities in the recent decade (Xiao et al., 2021; Xiao & Lu, 2021). Multilevel suicide interventions are needed to address interactions of social

determinants of health (SDoH): adverse childhood experiences, social networks, families, and healthy communities (Braslow et al., 2021). In particular, it is essential to take a comprehensive public health approach to prevent suicidal ideation in the first place, to identify people in need of early and equitable access, and to provide long-term social and economic support (Font & Maguire-Jack, 2016; Quinn et al., 2016; Stein et al., 2017). This is particularly true given the sociodemographic disparities observed in the psychological impact of the COVID-19 pandemic, during which social disconnections have surged substantially. Without a structural intervention across communities and legal action that proactively protects individuals from experiencing parental abuse and maltreatment during childhood, while improving social relationships from families to friends and neighborhoods, the existing racial/ethnic and socioeconomic disparities in suicide rates may be difficult to alleviate completely.

4.4. Limitations

This study has limitations. First, variables related to ACEs may be subject to recall bias since this information is obtained retrospectively. Second, there could be group differences across age, sex, race/ethnicity, and socioeconomic status in the causal effect of social networks on suicidal ideation (Font & Maguire-Jack, 2016). However, the sample sizes of these subpopulations were too small to conduct valid subgroup analyses. Future research should address such differences using longitudinal data with more diverse populations across sociodemographic characteristics. When necessary, oversampling racial/ethnic and sexual minority groups may help us to understand the underlying mechanisms driving suicide behaviors in these groups, which have increased substantially in recent years (Cha et al., 2018; Hughes et al., 2017; Xiao & Lindsey, 2021a). Lastly, while MIDUS samples were drawn from a nationally representative random-digit-dial sample of non-institutionalized middle-aged adults, the sample in our study is only approximately nationally representative.

5. Conclusions

Our study findings suggest that SNS causes increases in suicidal ideation among individuals with ACEs. Screening for early life adversities among individuals with psychiatric distress may effectively identify middle-aged adults at high risk for suicidal ideation. Suicide prevention by engaging and improving social networks shows promise in preventing suicidal behaviors. Policy efforts that reduce ACEs could be instrumental in reducing suicide at the structural level.

Author statement

Concept and design: All authors.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Brown.

Obtained funding: Xiao.

Administrative, technical, or material support: Xiao.

Ethical statement

We have reviewed the Ethics in Publishing and Ethical Guidelines for Journal Publication documents and confirm that we have abided by all ethical guidelines in the production of this manuscript. We have no competing interests or financial interests to disclose.

Funding/support

Dr. Xiao was supported by grant CORONAVIRUSHUB-D-21-00125

from the Bill & Melinda Gates Foundation.

Role of the funder/sponsor

The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Disclaimer

The content is solely the responsibility of the authors and does not represent the official views of the funders.

Financial disclosure

The authors have no financial relationships relevant to this article to disclose.

Ethical approval

This study was not required to obtain ethics approval since it uses publicly available data that contain no identifiable private information and is therefore not considered human subjects research by the Committee for the Protection of Human Subjects at the University of California. The authors did not have access to any personally identifiable information or information that would link the data to individuals' identities. All data are reported in aggregate to eliminate the possibility of deductive identification of individuals.

Data availability statement

Data sharing: Data are accessible through Inter-university Consortium for Political and Social Research (ICPSR). The public-use data files in this collection are available for access by the general public through <https://www.icpsr.umich.edu/web/ICPSR/series/203>. Access does not require affiliation with an ICPSR member institution. All Stata code is accessible from the corresponding author.

Conflict of interest disclosures

No conflicts of interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2022.101120>.

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