



A Longitudinal Network Analysis of the Interactions of Risk and Protective Factors for Suicidal Potential in Early Adolescents

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Abstract

Few studies have applied the “ideation-to-action” theories and the buffering hypothesis of resilience to suicide in early adolescents, and existing research is primarily cross-sectional. This study examined the interactions between risk factors (i.e., thwarted belongingness, perceived burdensomeness, and hopelessness), protective factors (i.e., resilience, self-efficacy, and subjective happiness), and suicidal potential (i.e., family distress, anxious-impulsive depression, and suicidal ideation or acts) in early adolescents. The participants ($N = 1615$; 55.6% females; $M_{\text{age}} = 10.93$, $SD_{\text{age}} = 1.14$, range: 9–15) who were recruited from four primary and four secondary schools in Hong Kong completed the survey in 2020 and 2021. The contemporaneous networks suggested that perceived burdensomeness and hopelessness were positively associated with suicidal potential. Protective factors were negatively associated with risk factors studied and suicidal potential. The node with the greatest centrality strength was anxious-impulsive depression. The nodes most likely to connect with other constructs were self-efficacy and hopelessness. A temporal network suggested the predictive effect of hopelessness and the protective effect of subjective happiness on future suicidal ideation or acts. Moreover, self-efficacy was found to buffer the impact of hopelessness on future suicidal ideation or acts. These findings highlighted the contribution of hopelessness to suicidal potential among early adolescents and the buffering effects of subjective happiness and self-efficacy.

Keywords Suicide · Interpersonal needs · Hopelessness · Self-efficacy · Subjective happiness

Introduction

Child and adolescent suicide is a significant public health issue worldwide. Suicidal ideation is defined as the idea or desire to end one’s life and, as with suicidal behaviors themselves, it leads to significant distress and pain for the afflicted individual (Jobs & Joiner, 2019). A meta-analysis of suicide-related studies including 686,672 children and adolescents reported an overall lifetime prevalence of suicidal ideation of 18% (Lim et al., 2019). In Hong Kong, the most recently reported suicide rates for youth under 15 (1.2 per 100,000 in 2020 and 1.7 per 100,000 in 2021) are lower

than those for other age groups. However, suicide rates have gradually increased from 2016 to 2021, with the most significant increase seen between 2020 and 2021 (Hong Kong Jockey Club Centre for Suicide Research and Prevention, 2022). The prevalence of suicidal ideation and suicide attempts among middle school children ranges from 3% to 13.7% (Siu, 2019). Among the 3522 Hong Kong youth in Grades 7–12, 21.8% reported suicidal ideation (Chang et al., 2019). Adolescents reporting suicidal ideation were 12 times more likely to attempt suicide by age 30 compared to those who did not report such ideations (Reinherz et al., 2006). Early adolescence (10–15 years old) is a crucial transitional period in human development, and is often considered the ‘crossroads’ between childhood and young adulthood (Caissy, 1994). Results from a prospective cohort study of suicide trajectories underscore the importance of finding vulnerability factors for suicide during adolescence, especially early adolescence (Erasquin et al., 2019; Geoffroy et al., 2021). This study examined suicidal potential among early adolescents based on the “ideation-to-action” theories and the buffering hypothesis of resilience to suicide using a cross-lagged panel network analysis.

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Suicidal Potential and Risk Factors

The last two decades of suicide research have largely focused on “ideation-to-action” theories, which focus on the transition from suicidal ideation to suicidal action and the influences of risk factors on this process (Klonsky et al., 2018). Among them, the Interpersonal Psychological Theory of Suicide (IPTS) (Joiner, 2005) is the most influential because it was the first “ideation-to-action” theory proposed (Klonsky et al., 2018). IPTS has been widely used in cross-national cultures and in both scientific and clinical contexts (Chu et al., 2017; Ma et al., 2016). IPTS emphasizes that thwarted belongingness and perceived burdensomeness are the main sources of suicidal ideation. Acquired capability for suicide is essential for people to progress from suicidal ideation to suicide attempts (Joiner, 2005). Forming and maintaining strong, stable interpersonal relationships is a basic psychological need. When this need is unmet (due to family conflicts, living alone, etc.), individuals feel lonely and lack care from others. Such individuals suffer from a psychological state of thwarted belongingness (Ma et al., 2019). When individuals perceive their existence as being burdensome to others (e.g., when they are unemployed and are unable to provide financial support to others) and have thoughts such as ‘I wish I were dead,’ they are considered as having perceived burdensomeness (Gratz et al., 2020). With increasing tolerance of physical pain and a decreasing fear of death (i.e., acquired capability for suicide), suicidal ideation may develop into suicidal behavior. Although systematic reviews and meta-analyses have shown that IPTS, particularly the predictive role of perceived burdensomeness, is supported by empirical evidence in adults (Chu et al., 2017; Ma et al., 2016), it has not been well studied in early adolescent populations. The few studies carried out in adolescent populations have reported weak and inconsistent evidence for the association of perceived burdensomeness and thwarted belongingness with suicidal ideation (Al-Dajani & Czyz, 2022; Stewart et al., 2017).

The Three-Step Theory (3ST) is another theory in the line of “ideation-to-action” theories, proposes that suicide is a three-step process (Klonsky & May, 2015). First, the combination of pain (largely psychological) and hopelessness triggers suicidal ideation. Next, this pain and hopelessness overwhelms any existing sense of connectedness (i.e., protective factors that make people feel that their life is worth living, such as feeling connected to a significant other), thereby enhancing suicidal ideation. The third step is the acquisition of the capacity to commit suicide, which leads to the escalation of suicidal ideation into suicidal action. Considerable research has reported that pain and hopelessness are more strongly associated with suicide than thwarted belongingness and perceived burdensomeness (Klonsky et al., 2021). However, the evidence supporting 3ST in early adolescents, particularly longitudinal evidence, is limited.

Notably, the order of the steps in 3ST is not chronological but logical; therefore, the timeframe of suicide risk escalation remains unclear (Klonsky et al., 2021). The Fluid Vulnerability Theory in the “ideation-to-action” theories proposes that it may not be sufficient to focus on only one (or a few) components of the suicide belief system as risk and protective factors are interactive and dynamic (Bryan & Rudd, 2016; Rudd, 2006). Recent network analyses and system dynamics and computational simulation modelling studies have highlighted that interactions within the suicide risk system are systematic, intensive, and dynamic (Chung et al., 2022; Rath et al., 2019). In other words, both contemporaneous and temporal interactions between risk and protective factors should be considered when studying suicidal potential system.

Suicidal Potential and Protective Factors

Although the role of protective factors is considered in ideation-to-action theories, empirical studies often do not interrogate the interactions between protective and risk factors. A meta-analysis of the 365 suicide studies carried out in the past 50 years showed that studies rarely investigated protective factors *a priori* (Franklin et al., 2017). Moreover, Franklin et al., (2017) highlighted the need for studies specifically designed to assess protective factors themselves, not just evaluate the opposite aspects of risk factors (e.g., no psychopathology). Scholars have also emphasized the need to study the defensive and buffering nature of resilience on suicide risk in children and adolescents (Ivbijaro et al., 2019; Johnson et al., 2011; Sher, 2019). Resilience can be referred to as the capacity to maintain normal mental and physical functioning in the face of adversity and stress or as a dynamic adaptation process in response to adversity and stress (Fergus & Zimmerman, 2005; Ivbijaro et al., 2019; Sher, 2019). In addition to being an inherent capability, specific aspects of resilience (e.g., self-efficacy, life evaluation, and life satisfaction) can interact with risk factors to reduce suicide risk (Knowles et al., 2021; Shahram et al., 2021). Self-efficacy is an individual’s fundamental belief in one’s ability to cope with life events (Bandura, 1977). Subjective happiness reflects an individual’s evaluation of their life from a positive perspective (Lyubomirsky & Lepper, 1999). It is reasonable to include resilience, self-efficacy, and subjective happiness as protective factors in the suicide system.

Network Analysis of Risk and Protective Factors for Suicidal Potential

Given the dynamic and systemic nature of suicide, researchers have advocated for the use of network analysis to explore the interplay between factors within the suicide

risk system in recent years (de Beurs et al., 2021). Network analysis is an analytical method that allows the interactions within psychobehavioural systems to be depicted as network structures (Epskamp et al., 2018). Recently, some scholars have attempted to apply this approach to “ideation-to-action” theories. For instance, a cross-sectional network analysis of a sample of 1586 university students found that reduced fear of death (i.e., acquired capability for suicide) and greater psychological distress were strongly associated with suicidal planning and behavior (Calati et al., 2022). A cross-sectional network analysis of 644 young people found that perceived burdensomeness, but not thwarted belongingness, was directly correlated with suicidal desire (Ordóñez-Carrasco et al., 2021). Other studies have considered the combination of risk and protective factors in terms of suicidal ideation. For example, a study of 515 adults reported that feeling depressed or hopeless, perceived burdensomeness, and self-esteem (i.e., self-acceptance, respect, and satisfaction) were the central nodes in a cross-sectional suicide network (Holman & Williams, 2022). A cross-sectional network analysis of 557 undergraduate students reported a positive influence of finding meaning in life, having hope, and having low negative affect on suicidal ideation (Oakey-Frost et al., 2022). A cross-sectional network analysis of “ideation-to-action” suicide theories with a sample of 3508 young people found that thwarted belongingness was associated with other factors within the network, but not directly with suicidal ideation (De Beurs et al., 2019). They reported a significant positive association between perceived burdensomeness, depression, and mental well-being (e.g., subjective happiness) and suicidal ideation. As such, network analysis prepares for practice-level empirical exploration and theory-driven research from an exploratory/non-theory-driven perspective.

It is reasonable to assume that network analysis holds the potential to expand the understanding of the interactions between risk and protective factors within the suicide risk system. Most previous network analyses have used cross-sectional, undirected networks. However, a recent study suggested that such cross-sectional networks fail to capture temporal changes in psychobehavioural systems and may differ substantially from longitudinal networks (Conlin et al., 2022). To date, only one study has longitudinally investigated the interaction between suicidal ideation and risk factors using ecological momentary assessment and network analysis (Rath et al., 2019). They found that among a sample of 74 psychiatric inpatients, later suicidal ideation was best predicted by early suicidal ideation rather than by hopelessness or thwarted belongingness (Rath et al., 2019). No longitudinal network studies have systematically investigated the interactions between suicidal ideation and risk and protective factors in early adolescents. To this end, improving the understanding of the associations between

essential risk factors, as proposed by “ideation-to-action” theories, protective factors, as proposed by the buffering hypothesis of resilience to suicide, and suicidal potential could provide valuable insight and new theoretical directions for practical youth suicide prevention.

Current Study

The key risk factors proposed by “ideation-to-action” theories and protective factors proposed by the buffering hypothesis of resilience to suicide interact, and thereby influence adolescent suicidal risk. A cross-lagged panel network analysis method provides a systematic perspective for examining suicide risk systems among early adolescents and for exploring the relationships between risk and protective factors. However, few studies have used network analysis methods to do this. Therefore, the first aim of this study was to use contemporaneous network analysis to separately assess and describe the core and bridging nodes of the suicide risk system at different time points. The second aim was to use the temporal network to explore the interactions of suicidal potential elements, risk factors, and protective factors. Given the complexity and data-driven nature of network analysis, the present study did not formulate specific hypotheses relating to the direct effect of suicidal potential. Based on the “ideation-to-action” theories and the buffering hypothesis of resilience to suicide, the current study hypothesized that risk factors (i.e., perceived burdensomeness, thwarted belongingness, and hopelessness) are associated with increased suicidal potential. In contrast, protective factors (i.e., resilience, self-efficacy, and subjective happiness) are associated with reduced suicidal potential.

Methods

Participants and Procedures

The Research Ethics Subcommittee of City University of Hong Kong approved the study to identify suicidal potential, risk factors, and protective factors related to suicide risk among early adolescents. The research team recruited early adolescents from four secondary and four primary schools in Hong Kong in 2020 using convenience sampling. This study was conducted with each school principals’ consent and teachers’ assistance. The inclusion criterion was all fifth- and sixth-grade students in primary schools and all first- and second-grade students in secondary schools. The exclusion criteria were (a) students who could not read Chinese and (b) students who had been clinically diagnosed with a mental illness. In total, 1744 eligible students were

Table 1 Demographic information ($N = 1615$)

	Frequency	Percentage
Gender		
Male	717	44.4%
Female	898	55.6%
Age in 2020		
9	95	5.9%
10	577	35.7%
11	175	10.8%
12	515	31.9%
13	59	3.7%
14	12	0.7%
15	2	0.1%
Missing	180	11.2%
Religion		
No	931	57.6%
Yes	469	29.0%
Missing	215	13.3%
Parental marital status		
Original marriage (parents had never divorced)	989	61.2%
Non-original marriage (including divorced, separated, bereaved, cohabited, or remarried)	351	21.7%
Missing	275	17.0%
Total Missing	297	18.4%

invited to participate in the survey. Social workers gave all recruited students and their guardians detailed descriptions of the research content and confidentiality measures. The research team also clarified to all participants that if they were uncomfortable at any time during the survey, they could terminate their involvement. All participants were supported by professional social workers, a 24-h emotional support hotline, and online emotional support services both during and after the survey. Both the students and their guardians provided written informed consent.

The pen-and-paper method was used for both waves of data collection. Due to the third wave of the COVID-19 pandemic occurring in Hong Kong from July to September 2020 (HKSAR Government, 2022), the government extended previously implemented social distancing measures. However, face-to-face education was permitted. As the epidemic subsided, Hong Kong students in primary and secondary schools resumed face-to-face classes as normal on September 23, 2020. From April 2021 to the end of the study in September 2021, COVID-19 cases in Hong Kong gradually subsided (HKSAR Government, 2022), and people returned to their everyday lives. It can be believed that the COVID-19 pandemic did not have a significant impact on data collection.

In total, 1744 participants completed the questionnaire between July and September 2020. Of these, 1615 participants (92.6% of the eligible participants; 717 males, 898 females; mean age = 10.93, standard deviation (SD) age = 1.14, range age: 9–15) completed the questionnaire again between July and September 2021. The demographic characteristics of the participants are summarized in Table 1.

Measures

Suicidal potential

The risk of suicide in early adolescents is measured using Child-Adolescent Suicidal Potential Index (Pfeffer et al., 2000). Among the 30 items included in this scale ($\alpha_{2020} = 0.88$, $\alpha_{2021} = 0.90$), eight items were used to assess family discord and psychopathology (i.e., family distress) ($\alpha_{2020} = 0.70$, $\alpha_{2021} = 0.73$). Individual psychiatric symptoms (i.e., anxious-impulsive depression) were measured by 16 items ($\alpha_{2020} = 0.83$, $\alpha_{2021} = 0.86$). Suicidal ideation or acts ($\alpha_{2020} = 0.84$, $\alpha_{2021} = 0.87$) was measured by six items. Participants received one point for answering “yes” and zero point for answering “no” to each item. The higher the total score, the greater the risk of suicide for the individual. Previous studies have shown that the scale has good internal consistency ($\alpha = 0.89$ – 0.90), discriminant validity, and convergent validity in children and adolescents (Pfeffer et al., 2000; Roxborough et al., 2012). The research team translated the scale into Chinese using a trilateral translation procedure (Beaton et al., 2000). A native Chinese psychology professor fluent in English translated the scale into Chinese. A professor of psychology, an individual with a PhD in psychology, and an individual with a PhD in social work proofread the Chinese translation. A native English-speaking translator retranslated the Chinese version of the scale into English. The expert group then discussed the differences between the two English versions and corrected the Chinese version to obtain a satisfactory Chinese scale. The final Chinese version of the scale was assessed using pre-testing and cognitive interviews to ensure cross-cultural equivalence and accuracy of wording.

Interpersonal needs

The 10-item Interpersonal Needs Questionnaire (Hill et al., 2015) was used to measure perceived burdensomeness (five items; $\alpha_{2020} = 0.84$, $\alpha_{2021} = 0.87$) and thwarted belongingness (five items; $\alpha_{2020} = 0.69$, $\alpha_{2021} = 0.74$). Cronbach's alpha for the entire scale was 0.83 in 2020 and 0.84 in 2021. Items were rated on a 3-point scale (0 = not at all true for me, 1 = a little true for me, 2 = very true for me). Three items in the thwarted belongingness subscale were reverse-coded. The 10-item Chinese version scale showed good

construct validity, internal consistency, and measurement invariance among adolescents (Lai & Boag, 2021).

Hopelessness

Perceived hopelessness was assessed using the 10-item Chinese version of the Hopelessness Scale (Shek, 1993). The scale has been reported as having acceptable internal consistency ($\alpha = 0.71\text{--}0.88$) in children and adolescents (Kwok & Shek, 2010; Shek, 1993). The participants assessed each item on a 4-point Likert scale. The mean score indicated the level of hopelessness perceived by each participant. Cronbach's alpha for the scale was 0.90 in 2020 and 0.92 in 2021.

Resilience

The 6-item Resilience subscale in the Chinese Positive Youth Development Scale (Shek et al., 2007) was adopted. This subscale has demonstrated good internal consistency and construct validity in children and adolescents (Low et al., 2017; Shek et al., 2007). The participants were asked to answer each item using a 7-point Likert scale. The participants' levels of resilience were reflected in their mean scores. Cronbach's alpha for the scale was 0.87 in 2020 and 0.90 in 2021.

Self-efficacy

The 7-item Self-efficacy subscale in the Chinese Positive Youth Development Scale (Shek et al., 2007) was used to assess self-efficacy. The scale has been reported as having adequate reliability and validity in children and adolescents (Shek & Ma, 2010; Shek et al., 2007). The participants responded on a 7-point Likert scale. Five items were reverse-coded. Higher mean scores reflected greater self-efficacy. Cronbach's alpha for the scale was 0.79 in 2020 and 0.83 in 2021.

Subjective happiness

Subjective happiness was evaluated using the 4-item Subjective Happiness Scale (Lyubomirsky & Lepper, 1999). Higher self-reported scores reflect greater subjective happiness levels. One item with a negative description was reverse-coded. Cronbach's alpha for the scale was 0.71 in 2020 and 0.75 in 2021. The Chinese version of the scale is suitable for both children and adolescents (Kwan & Kwok, 2021).

Statistical Analysis

Descriptive analyses and independent t-tests were performed using SPSS 26.0 (IBM Corp, 2019). Based on the guidance for cross-lagged panel network analysis

(Rhemtulla et al., 2021), the contemporaneous and temporal networks were estimated in R 4.1.2 (R Core Team, 2022). The graphical least absolute shrinkage and selection operator estimation algorithm with Extended Bayesian Information Criterion (EBICglasso) in the Gaussian Graphical Model (Epskamp et al., 2018) was used to estimate the contemporaneous networks. Greater centrality (i.e., edge, strength, expected influence) and bridge metrics (i.e., bridge strength) were considered a reflection of stronger connections between the nodes, greater influence of the nodes within the network, and greater node strengths to bridge other nodes (Epskamp et al., 2018; Jones et al., 2021). The least absolute shrinkage and selection operator regularization with 10-fold cross-validation was adopted to estimate the temporal network (Rhemtulla et al., 2021). Higher cross-lagged in-prediction values indicated that the later node was influenced to a greater extent by all other nodes at the previous time point. In contrast, a lower cross-lagged out-prediction value indicated that an earlier node had a more significant influence on all other nodes at the later time point (Rhemtulla et al., 2021). Similar to Zainal & Newman, (2022), a multiple imputation method was adopted to impute the missing data on age, religion, and parental marital in the "mice 3.14.0" package (van Buuren & Groothuis-Oudshoorn, 2011). Based on differences in critical demographic variables (see Table 2), gender, age, and parental marital status were set as covariates in the temporal network. According to the literature, there is inconsistent empirical evidence to support the relationship religiosity and suicide risk (Dew et al., 2008; Lawrence et al., 2016). Therefore, the presence or absence of religiosity was also used as a control variable. The temporal network was run with and without multiple imputations, with the results showing no significant change in temporal network patterns. Details are provided in the supplementary material. Finally, the random 5000 "nonparametric" type and 5000 "case-drop" type bootstraps were performed to test the accuracy and stability of the networks. Correlation stability coefficients (CS-coefficient) higher than 0.5 were considered a reflection of network accuracy and stability (Epskamp et al., 2018; Rhemtulla et al., 2021). The detailed codes and results are available on the Open Science Framework (link: <https://osf.io/r26uq/>). The codes and results reported all the manipulations and all the measures analyzed in this study.

Results

Contemporaneous Networks

The kurtosis and skewness statistics shown in Table 3 indicate that the data in this study were normally

Table 2 Independent *t*-tests of baseline differences in key variables on demographic information with multiple imputation in 2020 ($N = 1615$)

	Gender					Age					
	Male ($n = 717$)		Female ($n = 898$)		<i>t</i>	<i>p</i>	Cohen's <i>d</i>	9–11 ($n = 960$)		12–15 ($n = 655$)	
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)				<i>t</i>	<i>p</i>	Cohen's <i>d</i>	
Subjective happiness	4.79 (1.16)	4.84 (1.09)	−0.96	0.336	0.04	4.87 (1.13)	4.74 (1.12)	2.32	0.020	0.12	
Self-efficacy	4.15 (0.95)	4.18 (0.94)	−0.80	0.422	0.03	4.18 (0.97)	4.15 (0.90)	0.52	0.604	0.03	
Resilience	4.42 (1.04)	4.45 (1.01)	−0.53	0.594	0.03	4.48 (1.05)	4.36 (0.99)	2.38	0.018	0.12	
Perceived burdensomeness	1.78 (2.20)	1.64 (2.17)	1.28	0.200	0.06	1.73 (2.22)	1.66 (2.12)	0.57	0.566	0.03	
Thwarted belongingness	2.90 (2.15)	2.53 (2.10)	3.45	0.001	0.17	2.61 (2.14)	2.81 (2.11)	−1.79	0.073	0.09	
Hopelessness	2.11 (0.62)	2.04 (0.62)	2.31	0.021	0.12	2.05 (0.64)	2.09 (0.58)	−1.08	0.279	0.05	
Anxious-impulsive depression	6.13 (4.11)	6.58 (4.04)	−2.18	0.030	0.11	6.11 (4.02)	6.78 (4.12)	−3.27	0.001	0.16	
Suicidal ideation or acts	0.91 (1.56)	0.83 (1.55)	1.03	0.302	0.05	0.86 (1.54)	0.88 (1.57)	−0.29	0.774	0.01	
Family distress	1.73 (1.77)	1.58 (1.63)	1.72	0.085	0.09	1.69 (1.77)	1.59 (1.56)	1.22	0.224	0.06	

	Religion					Parental marital status					
	No ($n = 1068$)		Yes ($n = 547$)		<i>t</i>	<i>p</i>	Cohen's <i>d</i>	Non-original marriage ($n = 417$)		Original marriage ($n = 1198$)	
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)				<i>t</i>	<i>p</i>	Cohen's <i>d</i>	
Subjective happiness	4.81 (1.12)	4.83 (0.12)	−0.28	0.782	0.01	4.55 (1.17)	4.91 (1.09)	−5.73	<0.001	0.29	
Self-efficacy	4.17 (0.95)	4.16 (0.93)	0.16	0.874	0.01	3.99 (0.97)	4.23 (0.93)	−4.39	<0.001	0.22	
Resilience	4.42 (1.05)	4.45 (0.98)	−0.49	0.622	0.02	4.21 (1.12)	4.51 (0.98)	−5.11	<0.001	0.25	
Perceived burdensomeness	1.69 (2.15)	1.73 (2.25)	−0.34	0.737	0.02	2.25 (2.39)	1.51 (2.07)	6.08	<0.001	0.30	
Thwarted belongingness	2.71 (2.13)	2.67 (2.13)	0.35	0.729	0.02	3.14 (2.19)	2.54 (2.08)	5.01	<0.001	0.25	
Hopelessness	2.08 (0.62)	2.05 (0.62)	1.07	0.285	0.05	2.22 (0.65)	2.02 (0.60)	5.77	<0.001	0.29	
Anxious-impulsive depression	6.34 (4.10)	6.45 (4.04)	−0.51	0.609	0.03	6.90 (4.06)	6.20 (4.07)	3.05	0.002	0.15	
Suicidal ideation or acts	0.84 (1.54)	0.91 (1.58)	−0.86	0.388	0.04	1.21 (1.75)	0.75 (1.46)	5.33	<0.001	0.27	
Family distress	1.62 (1.66)	1.71 (1.74)	−1.07	0.285	0.05	2.08 (1.88)	1.50 (1.59)	6.07	<0.001	0.30	

Table 3 Mean (*M*), standard deviation (*SD*), skewness, and kurtosis of suicidal potential, risk factors, and protective factors ($N = 1615$)

	2020				2021			
	<i>M</i>	<i>SD</i>	Skewness	Kurtosis	<i>M</i>	<i>SD</i>	Skewness	Kurtosis
Subjective happiness	4.82	1.12	−0.29	0.03	4.81	1.13	−0.23	−0.16
Self-efficacy	4.17	0.94	−0.29	−0.18	4.20	0.96	−0.26	−0.19
Resilience	4.43	1.03	−0.62	0.30	4.46	1.06	−0.68	0.56
Perceived burdensomeness	1.70	2.18	1.47	1.64	1.73	2.23	1.46	1.68
Thwarted belongingness	2.69	2.13	0.78	0.25	2.68	2.21	0.72	0.02
Hopelessness	2.07	0.62	0.60	−0.03	2.05	0.62	0.53	−0.11
Anxious-impulsive depression	6.38	4.08	0.19	−0.88	6.35	4.34	0.25	−0.96
Suicidal ideation or acts	0.87	1.55	1.83	2.34	0.82	1.59	1.95	2.65
Family distress	1.65	1.69	1.08	0.61	1.56	1.67	1.22	0.94
Suicidal potential	8.90	6.21	0.53	−0.40	8.73	6.48	0.58	−0.38

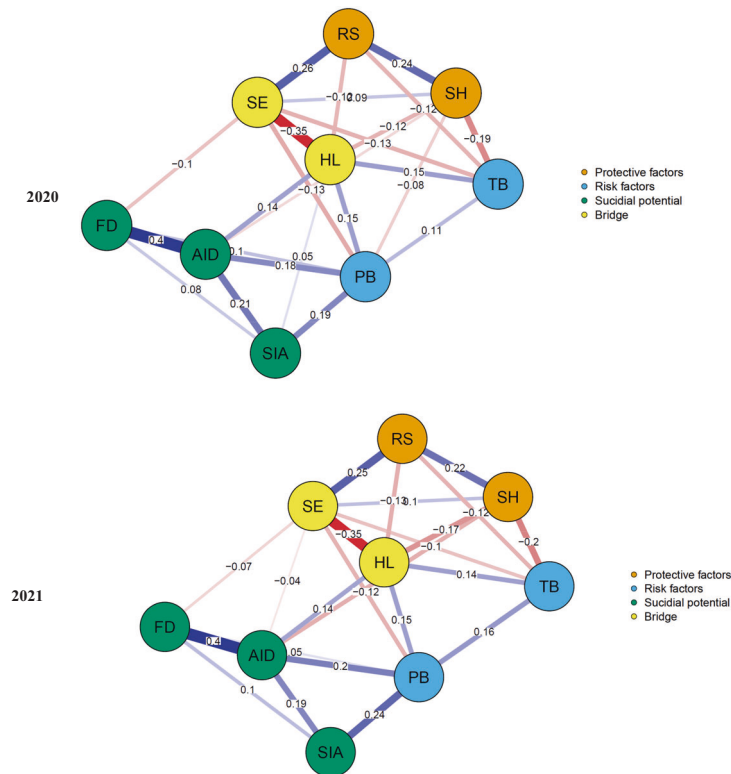
distributed. The contemporaneous networks of suicidal potential, risk factors, and protective factors in 2020 and 2021 are presented in Fig. 1. In the 2020 network, 66.67% (24/36) of all possible edges were preserved. In the 2021 network, 63.89% (23/36) of all possible edges were maintained.

Across the suicidal potential cluster and the risk factors cluster, the strongest undirected edges were anxious-

impulsive depression–perceived burdensomeness ($r_{2020} = 0.18$, $r_{2021} = 0.20$), anxious-impulsive depression–hopelessness ($r_{2020} = 0.14$, $r_{2021} = 0.14$), and suicidal ideation or acts–perceived burdensomeness ($r_{2020} = 0.19$, $r_{2021} = 0.24$).

Across the suicidal potential cluster and the protective factors cluster, the strongest undirected edges were anxious-impulsive depression–subjective happiness ($r_{2020} = -0.06$, $r_{2021} = -0.13$) and family distress–self-efficacy ($r_{2020} = -0.10$,

Fig. 1 Contemporaneous networks and the top 20% bridge factors based on the bridge strength in 2020 and 2021 ($N = 1615$). Values are regularized partial correlations. AID Anxious-impulsive depression, SIA Suicidal ideation or acts, FD Family distress, PB Perceived burdensomeness, TB Thwarted belongingness, HL Hopelessness, RS Resilience, SE Self-efficacy, SH Subjective happiness



$r_{2021} = -0.07$). The correlation between risk and protective factors was negative ($r = -0.08$ – -0.35). All undirected edge results are detailed in Table S1 in the supplementary.

In 2020 and 2021, self-efficacy (bridge strength = 0.68 – 0.71) and hopelessness (bridge strength = 0.78 – 0.79) had the greatest bridge strengths (refer to Fig. S1). Anxious-impulsive depression in the suicidal potential (strength = 0.87 – 1.25 , expected influence = 1.32 – 1.59) had the greatest node strength centrality (refer to Table S2 and Fig. S2).

The network accuracy and correlation stability analysis showed good accuracy and stability of edges (CS-coefficient = 0.75 , 95% CI = [0.672 , 1.000]), centrality strength (CS-coefficient = 0.75 , 95% CI = [0.672 , 1.000]), and bridge strength (CS-coefficient = 0.75 , 95% CI = [0.672 , 1.000]) (refer to Figs. S3, S4).

Temporal Network

The cross-lagged network results for the suicidal potential system are shown in Fig. 2. For results with missing covariate data, refer to Fig. S5. The arrows indicate the temporal association between the nodes. Anxious-impulsive depression ($\beta = 0.52$), family distress ($\beta = 0.46$), and suicidal ideation or acts ($\beta = 0.45$) were the nodes with the greatest auto-regression coefficients (refer to Fig. S7).

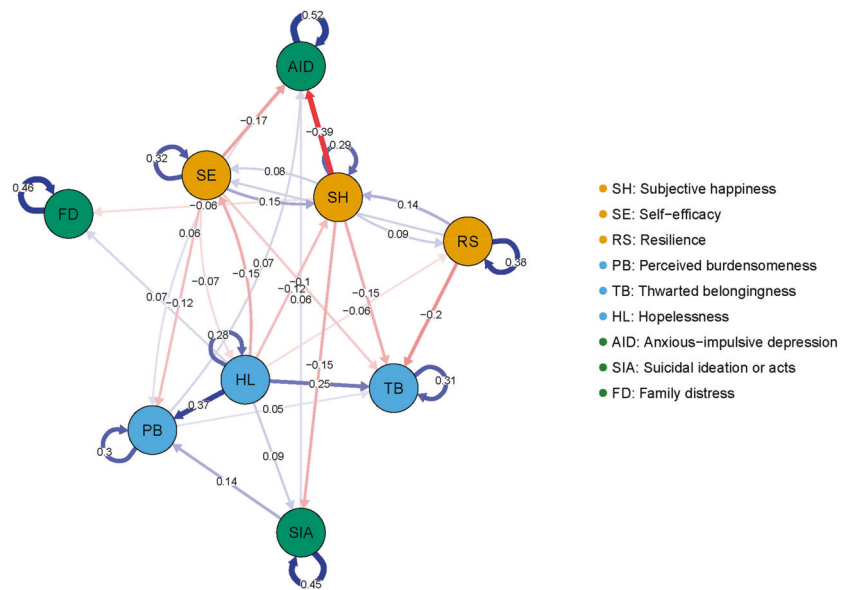
A high level of hopelessness in 2020 was associated with higher family distress ($\beta = 0.07$) and a higher level of suicidal ideation or acts ($\beta = 0.09$) in 2021. Moreover, a high level of perceived burdensomeness in 2020 was associated with higher anxious-impulsive depression ($\beta = 0.07$) in 2021.

A higher level of self-efficacy in 2020 was prospectively associated with lower anxious-impulsive depression ($\beta = -0.17$) in 2021. Higher subjective happiness in 2020 was associated with lower anxious-impulsive depression ($\beta = -0.39$), lower suicidal ideation or acts ($\beta = -0.15$), and lower family distress ($\beta = -0.06$) in 2021.

Negative unidirectional or bidirectional temporal associations were observed between protective factors and risk factors ($\beta = -0.07$ – -0.20). Higher self-efficacy in 2020 was associated with reduced hopelessness in 2021 ($\beta = -0.07$), while hopelessness is positively associated with suicidal ideation or acts. The directed edge results are detailed in Table S3 in the supplementary.

Figure 3 shows the cross-lagged centrality results. See Table S4 for more details. The most influential nodes with low in-prediction and high out-prediction values were hopelessness (in-prediction = 0.21 , out-prediction = 1.11) and subjective happiness (in-prediction = 0.45 , out-predicted = 0.96). Perceived burdensomeness (in-prediction = 0.71 , out-prediction = 0.24), thwarted belongingness (in-

Fig. 2 The temporal network of the suicidal potential, risk factors, and protective factors from 2020 to 2021 ($N = 1615$). The threshold = 0.05 was set for the sake of simplicity of the graph. Only predicted paths with $\beta > 0.05$ are plotted in the figure



prediction = 0.79, out-prediction = 0.07), and anxious-impulsive depression (in-prediction = 0.70, out-prediction = 0.15) had limited impact on other nodes but were greatly affected by other nodes. Suicidal ideation or acts (in-prediction = 0.38, out-prediction = 0.25) was susceptible to other nodes rather than influence other nodes in the network.

Bootstrapping revealed that the temporal network was stable in terms of edges (CS-coefficient = 0.672, 95% CI = [0.439, 1.000]), in-prediction (CS-coefficient = 0.672, 95% CI = [0.439, 1.000]), and out-prediction (CS-coefficient = 0.672, 95% CI = [0.439, 1.000]) (refer to Figs. S8, S9).

Discussion

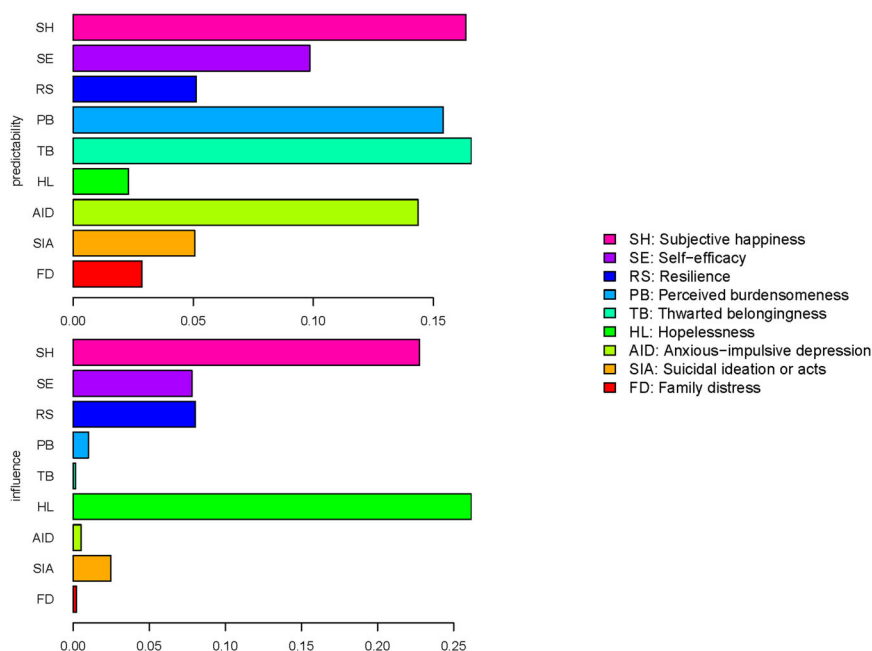
Theoretically, risk and protective factors interact with and influence suicidal potential. However, the exact mechanisms by which these factors interact remains unclear, especially among early adolescents. This study explored how risk and protective factors interact with suicide potential based on “ideation-to-action” theories and the buffering hypothesis of resilience to suicide using a longitudinal design in 2020 and 2021. When risk and protective factors were included in the suicidal potential network, this study found that anxious-impulsive depression in the suicidal potential was the most central of all network nodes. Self-efficacy was the bridge node between protective factors and suicidal potential. Hopelessness was the bridging node between suicidal potential and risk factors. From 2020 to 2021, the previous suicidal potential was the strongest predictor of suicidal potential at the latter point in time. Of the risk factors examined, hopelessness had the strongest association with suicide potential at the later time point.

Among the protective factors, subjective well-being had the strongest negative association with suicidal potential at the later time point. In addition, self-efficacy was found to reduce suicidal potential by decreasing hopelessness.

Consistent with the overall hypothesis, both the contemporaneous and temporal networks suggested that risk factors (i.e., perceived burdensomeness, thwarted belongingness, and hopelessness) were associated with increased suicidal potential. In contrast, protective factors (i.e., resilience, self-efficacy, and subjective happiness) were associated with reduced suicidal potential. In the contemporaneous networks, perceived burdensomeness and hopelessness were found to be positively related to suicidal potential (i.e., anxious-impulsive depression and suicidal ideation or acts). The protective factors related to suicidal potential directly and via negative correlations with perceived burdensomeness and hopelessness. These findings are consistent with previous studies involving cross-sectional suicide network analysis, which have reported a stronger relationship between suicide risk and perceived burdensomeness and/or hopelessness than thwarted belongingness (De Beurs et al., 2019; Holman & Williams, 2022; Ordóñez-Carrasco et al., 2021).

It is worth noting that the temporal network did not fully map the pattern of relationships in the contemporaneous networks. The temporal network results aligned better with the 3ST theory than with IPTS among early adolescents. Specifically, rather than thwarted belongingness and perceived burdensomeness, hopelessness was prospectively associated with later suicidal ideation or acts. This finding is consistent with a previous study on the ecological momentary assessment of suicidal ideation, which reported that hopelessness was a stronger predictor of suicidal

Fig. 3 The cross-lagged in-prediction (predictability) and out-prediction (influence) in the estimated temporal network ($N = 1615$)



ideation than burdensomeness and loneliness (Kleiman et al., 2017). Studies of community and clinical samples have identified pain and hopelessness as greater motivators of suicide than thwarted belongingness and perceived burdensomeness (May et al., 2020). Overwhelming pain and hopelessness (especially when the person experiencing the pain is hopeless about their situation improving) (Klonsky et al., 2021) are acute triggers of suicidal ideation. In contrast, perceived burdens and frustrating feelings of belonging may improve with time and effort and are susceptibility factors for suicidal ideation. Therefore, when formulating practical strategies to prevent early suicide among early adolescents, priority should be given to reducing the hopelessness of participants, followed by long-term interventions to increase their sense of belonging and reduce their sense of being burdensome.

On the contrary, although Rath et al., (2019) reported that hopelessness accompanied high levels of suicidal ideation, their network analysis of ecological momentary assessment data suggested that hopelessness and perceived burdensomeness only predicted suicidal ideation in the present but not the future. A possible explanation for the inconsistent results is that the participants in the present study (i.e., early adolescents) differed from those in the Rath et al., (2019) study (i.e., psychiatric inpatients). A recent system dynamics simulation study of four waves of longitudinal data from 20,000 adolescents suggested that IPTS does not adequately predict the changes in suicide attempts during the transition from adolescence to adulthood (Chung et al., 2022). An intensive longitudinal data analysis of adolescent psychiatric inpatients showed that

models combining hopelessness and self-efficacy to refrain from suicidal action were the most sensitive predictors of suicide risk, rather than models including perceived burdensomeness or thwarted belongingness (Czyz et al., 2020). Another possible explanation is the emotional impact of the COVID-19 epidemic on the early adolescents in the current study. An analysis of 35 registered suicide cases in 2016 among Hong Kong primary and secondary school students (10–20 years) found that school stress, family problems, and psychological maladjustment were the most vital risk factors for adolescent suicide (Wong et al., 2022). During the data collection period of this study, the COVID-19 outbreak in Hong Kong was intermittent, with strict social distancing policies in place (HKSAR Government, 2022). Social distancing during COVID-19 can exacerbate students' feelings of isolation and lead to problematic gaming behaviors that affect academic performance, and the academic stress of adapting to online education following school closures might have enhanced depressive symptoms and online gaming behaviours in children and adolescents (She et al., 2021; Zhu et al., 2021). In Hong Kong, where competition for study and work is fierce, mental distress resulting from the pressure to perform well academically, combined with parental expectations and emotional imbalances triggered by social factors (e.g., housing problems, inequality, and COVID-19), have undoubtedly contributed to the increase in early adolescent suicide rates in recent years (Wong & Chan, 2019). This finding suggested that the interaction of suicidal potential and risk factors is highly dynamic. When formulating preventive strategies, it will be necessary to

adapt to local conditions, contemporaneous societal events, and different types of participants.

The temporal network revealed that subjective happiness was negatively associated with future suicidal ideation or acts, whereas self-efficacy could influence future suicidal ideation or acts by modulating helplessness. On the one hand, These findings illustrate the applicability of the buffering hypothesis of resilience to suicide in the context of early adolescents, as reported by several previous cross-sectional network analysis studies (De Beurs et al., 2019; Fonseca-Pedrero et al., 2022; Holman & Williams, 2022). On the other hand, these results highlight the importance of resilience-promoting interventions, especially those that promote subjective happiness and self-efficacy, for suicide prevention among early adolescents. Previous meta-analysis results have revealed that interventions that improve suicide prevention knowledge and skills, enhance self-efficacy, and promote positive mental health could significantly reduce suicidal ideation and acts (Kacic et al., 2021; Wolitzky-Taylor et al., 2020).

Although this study provides insights into the theory and practice of early adolescent suicide prevention, there are some limitations. First, network analysis is essentially an exploratory, data-driven analytical approach. The current findings should be interpreted as generating hypotheses rather than as a verification of causal relationships (Liu et al., 2021). The results of this study should be interpreted with caution. Including qualitative analyses of early adolescent suicide influencing factors in future studies could complement the results of quantitative analyses and frame the findings in specific contexts and cultures. Second, future network analyses should include a richer set of variables. Other variables discussed in the ITPS and the 3ST (e.g., acquired capability for suicide and pain) were not included in the current study in order to ensure the simplicity of the questionnaire and reduce the burden on participants. In addition, variables from the other “ideation-to-action” theories and external protective factors (e.g., social support) (Shahram et al., 2021) were not included. Such factors are worthy of attention in future studies. Third, future research should be conducted using longitudinal networks with multiple timepoints that consider ecological momentary assessment and objective measures to capture more subtle and systematic changes in suicidal ideation and natural and dynamic changes in suicidal ideation and behavior among early adolescents. Finally, given the influence of age and culture on suicide (Snowdon, 2018), the findings of this study may not be generalizable to other age and cultural groups. Therefore, future studies should test the reproducibility of the current findings across different populations and cultures to increase validity.

Conclusion

The current findings demonstrated that anxious-impulsive depression was the most central symptom in the suicide network of early adolescents. Hopelessness in the risk factors and subjective happiness in the protective factors showed the most significant bridge effects with suicidal potential. Hopelessness, subjective happiness, and self-efficacy were critical for influencing future suicidal potential. This study is the first longitudinal network analysis to systematically explore suicidal potential among early adolescents. The current findings strengthen the application of network analysis methods in suicide research and enrich the evidence for the “ideation-to-action” theories and the buffering hypothesis of resilience to suicide among early adolescents. The results of this study provide important insights into targeted and systematic mental health intervention strategies for youth suicide prevention.

Authors' Contributions Y.L. contributed to the study design, conducted the statistical analysis, interpreted the findings, and drafted the manuscript; S.Y.C.L.K. contributed to the design of the study, interpretation of the findings, and made critical revisions to the manuscript. Both authors have read and approved the final version of this manuscript.

Data Sharing Declaration The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Ethics Approval The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. This study was conducted with the approval of the College Human Subjects Ethics Sub-Committee College of Liberal Arts and Social Sciences of the City University of Hong Kong (9239001).

Informed Consent All the participants and their guardians provided written informed consent.

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