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Unveiling Multifaceted Research Insights from Nearly Two Decades of Suicide Prevention Efforts in Taiwan

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Suicide prevention efforts in Taiwan have evolved over nearly two decades, with government support dating back to 2005. The implementation of the Suicide Prevention Act in 2019 marked a significant milestone. However, the emergence of COVID-19 in 2020 brought about economic, interpersonal, and societal changes that impacted individual vulnerability and the overall capacity for long-term care and medical services. As Taiwan transitions into the post-COVID era, there is a pressing need to address the rising suicide rates, particularly among two high-risk groups: young individuals aged 15-24 and the elderly population aged over 65. Key issues encompass understanding the causes of suicide attempts and ideation, including a notable increase in jumping suicides among young females, as well as the complex factors contributing to elderly suicide and caregiver suicidality.

This journal issue presents a comprehensive array of articles spanning various categories, collectively delving into the multifaceted realm of suicide and related subjects. Within the review articles, one paper meticulously examines the nexus between neuroinflammation in bipolar disorder and suicide, while another illuminates the therapeutic potential and future prospects of light therapy in addressing depression. In the featured articles section, an insightful piece introduces the Taiwan Suicide Prevention Act and provides insights into its implementation.

The original articles section presents a spectrum of research endeavors. It encompasses a preliminary investigation into the validity of the Five-item Suicide Narrative Inventory (SNI-5) for identifying suicidality in the general population through an online survey conducted in Taiwan. Additionally, a study delves into the physical and psychiatric diagnoses preceding suicidal deaths among the elderly, drawing from a national population-based study spanning from 2006 to 2015. Another study examines suicidality and psychological distress within caregivers of chronic patients through a cross-sectional questionnaire study. Moreover, a nationwide population-based study, spanning over seventeen years in Taiwan, delves into demographic trends, suicide methods, and underlying causes of suicide attempts in Taiwan during 2006-2023. Finally, a nationwide survey explores the impact of COVID-19 stressors, psychological distress, and suicidality on the general public in Taiwan. Lastly, the case reports section offers an illuminating account, focusing on a 15-year-old male diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) who recently made a suicide attempt. These articles collectively offer a nuanced and holistic perspective, advancing our understanding of suicide-related matters and providing valuable insights and evidence to bolster suicide prevention initiatives.

(This editorial was initially composed by the author and subsequently enhanced through collaboration with ChatGPT, followed by a final manual revision.)

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Neuroinflammation and Suicide in Bipolar Disorder

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Abstract: Bipolar disorder (BD) is a severe psychiatric condition characterized by mood lability, which poses the highest risk of suicide of any psychiatric illness. BD patients exhibit chronic neuroinflammation, especially during mood episodes, affecting cytokine levels in both the central nervous system and peripheral circulation. Genetic and environmental factors can trigger or exacerbate neuroinflammation, with disrupted sleep patterns and stressful life events being significant environmental triggers. This, in turn, leads to glial activation, mitochondrial disruption, and oxidative stress. Dysfunctional kynurenine and oxidative stress pathways have been implicated in the inflammatory process in BD, leading to synaptic deficits and neuronal loss associated with mood regulation and impulsivity. Evidence suggests that lithium confers neuroprotective effects and reduces suicide rates in BD. Other potential anti-inflammatory modulators such as ketamine have also shown efficacy in reducing suicidal ideation or managing BD symptoms. While treatments and lifestyle interventions targeting neuroinflammation may show promise in the future, further research is needed to understand the complex interplay between inflammation, mood, and suicidal behavior in BD. Efforts to identify personalized treatments considering individual neuroinflammatory profiles are crucial in improving outcomes for BD patients, particularly those at high risk for suicidal behavior. Overall, this narrative review highlights emerging evidence of neuroinflammation as one of the key pathophysiologies in BD and discusses new treatments targeting neuroinflammation to reduce the severity of mood symptoms and suicide rates in this vulnerable population.

Keywords: bipolar disorder, neuroinflammation, suicide, suicide prevention, microglia.

Introduction

Bipolar disorder (BD) is marked by episodic mood fluctuations, changes in psychomotor activity, and sleep disturbances, imposing a substantial burden of morbidity and mortality. BD impacts approximately 1-5% of the global population, and often manifests as recurrent episodes of elevated, irritable, or depressed mood, accompanied by interepisodic phases marked by subthreshold symptoms [1]. The disorder is classified into four main subtypes: bipolar I disorder, bipolar II disorder, cyclothymia, and bipolar disorder not otherwise specified. Bipolar I disorder can be identified by a manic episode marked by an abnormal mood, ranging from euphoric to irritable, coupled with heightened energy, lasting for at least seven days. Conversely, hypomanic episodes in bipolar II disorder are less intense, enduring four to seven days, and associated with fewer functional impairments. The chronic nature of BD, particularly concerning depressive phases and cognitive impairment, significantly contributes to disability and poses challenges for achieving functional recovery due to the persistence of residual and subthreshold symptoms between mood episodes.

BD carries one of the highest suicide risks among psychiatric illnesses [2]. Suicidal behavior (SB), ranging from suicidal ideation (SI) to suicide attempts (SA) and completed suicide, presents a grave public health concern, causing physical harm, loss of life, and significant socio-economic impacts. Mental disorders are closely tied to suicide, and approximately 90% of suicide victims have at least one mental disorder [3,4]. BD patients face a 20–60-fold elevated suicide risk, with 30–50% attempting suicide and 15–20% succumbing to it [2]. The intricate interplay of biological, psychological, and social factors contributing to SB, makes precise individual risk prediction challenging. BD patients have a shortened life expectancy due to suicide and higher rates of other medical conditions such as cardiovascular disease and diabetes [5,6]. While genetics, stressors, neurotransmitter systems, and neuropsychological factors are implicated in SB, pathophysiological mechanisms remain largely elusive.

Patients with BD exhibit substantial clinical heterogeneity due to a complex etiology involving interactions at the molecular, cellular, and individual levels. Nevertheless, a consistent link exists between BD and inflammation-associated medical conditions. These include cardiovascular diseases, obesity, insulin resistance, and autoimmune disorders—hinting at systemic inflammatory mechanisms [5,6]. Growing

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evidence suggests that a subset of BD patients experience chronically elevated inflammatory comorbidities, intensified during mood episodes [7–9]. This process is associated with glial activation, impacting serotonin metabolism, leading to oxidative stress and glutamatergic overactivation, which may result in synaptic and brain circuit abnormalities for BD patients.

This review aims to offer a comprehensive grasp of the impact of neuroinflammation on suicidal tendencies among BD individuals, along with recommendations for risk mitigation. It delves into the potential triggers and pathways of neuroinflammation in BD and explores how the neuro-inflammatory environment could contribute to elevated SB and clinical comorbidities in a subset of BD patients. This review summarizes recent evidence supporting therapies with anti-inflammatory properties that target mood symptoms and suicide in BD.

Methods

We conducted a systematic literature review to investigate the relationship between neuroinflammation and suicidality in BD. To do so, we thoroughly searched electronic databases were thoroughly searched using specific keywords and controlled vocabulary terms, with no restrictions on publication dates. Studies focusing on BD patients were selected and categorized based on the specific risk factors or biological pathways driving neuroinflammation. Based on a preliminary search of existing literature, inclusion criteria for this narrative review were refined to encompass studies concerning the neuro-inflammatory environment's impact on suicidal behavior and clinical comorbidities in BD. Notably, studies extrapolating from pre-clinical animal models were excluded due to the paucity of literature on suicide in these contexts. Furthermore, the review synthesizes findings from therapeutic interventions with anti-inflammatory properties targeting mood symptoms and suicide, encompassing treatments such as lithium and ketamine. Additionally, other modulators of neuroinflammation and ongoing clinical trials were also considered.

Neuroinflammation in Bipolar

Disorder

While some variation exists among studies, a subset of individuals with BD appears to manifest chronically elevated levels of low-grade proinflammatory cytokines in both the central nervous system (CNS) and peripheral circulation [7–9]. Expression patterns of these cytokines appear to be influenced by the disease stage (early, late) and phase (manic, euthymic, depressed), as well as medication status [7–9]. Between manic and depressive episodes, BD patients display heightened levels of serum tumor necrosis factor-alpha (TNF-α) and its receptor (TNF-αR1), interleukins including IL-1β, IL-2 and its receptor (IL-2R), IL-4, and IL-6 and its receptor (IL-6R) [10,11]. TNF-α has garnered attention due to its association with the most significant effect size in meta-analyses [10]. TNF-α is secreted by microglia to recruit monocytes to the CNS, which ultimately upregulates the inflammatory state [10]. Studies have not found significant differences in the levels of anti-inflammatory cytokines (IL-10) in BD subjects [12].

Specific inflammatory markers in peripheral circulation seem to be selectively enhanced during acute mood episodes, especially TNF-α [7–10]. The manic phase features heightened levels of IL-1β, IL-6, IL-6R, and IL-2R [7–9]. While conflicting results arise in other stages, the acute phase reactant C-reactive protein (CRP) appears to be elevated in manic episodes when compared to other disease stages [10]. A small study on treatment outcomes discovered that post-mania, IL-6 levels reduced (not TNF-α) after six weeks of treatment [13]. Additionally, during the manic phase, BD subjects demonstrated reduced anti-inflammatory cytokines levels [13]. To conclude, several studies indicate altered states of immune cytokines in BD; however, they produce varying results. This divergence could arise from the heterogeneity inherent to the bipolar spectrum disorder or constraints in quantifying serum immunocytokine levels. It is important to recognize that serum immunocytokine levels only estimate an approximation of the inflammatory condition and may not accurately reflect the genuine levels of inflammatory markers in the brain.

During depressive stages, meta-analysis suggests BD subjects exhibit an inflammatory profile akin to mania characterized by elevated concentrations of pro-inflammatory cytokines [8]. During depressive episodes, BD patients show higher levels of TNF-αR1 and IL-6R, even when compared to subjects with major depressive disorder (MDD), signifying distinct pathophysiological features in bipolar depression when compared to unipolar depression [11,14]. Interestingly, the presence of elevated pro-inflammatory cytokines, especially IL-6, during depressive phases is associated with an increased likelihood of transitioning to a manic episode [10].

Careful consideration is essential when interpreting results from peripheral serum immunocytokine measurements. This is because the alignment between neuroinflammation and peripheral tissue inflammation might not always be direct. Serum marker levels in the bloodstream may not accurately reflect the immunological activity occurring in the brain. While inflammatory marker levels within the cerebrospinal fluid (CSF) present a more reliable indicator, their clinical applicability is impeded by the necessity for post-mortem analysis to procure these measurements.

Considering the context, it is important to note that increased permeability of the blood-CSF barrier in individuals with BD can also introduce a confounding factor. This increased permeability facilitates the movement of plasma proteins into the CSF, consequently resulting in elevated CSF levels [15]. This observation corresponds with the findings of Jakobsson and colleagues, who conducted a study encompassing over 200 BD patients undergoing mood stabilizer treatment. They found that peripheral inflammation increased blood-brain permeability, leading to an increased expression of neuroinflammatory CSF markers [16]. This pattern persisted even after accounting for potential confounding variables. Lin et al. has conducted some preliminary studies examining the potential relationship between inflammation and structural changes in the

brain, however they have only examined BD offspring and not BD patients directly [17,18].

Additionally, during manic states, higher levels of inflammation are linked to decreased brain-derived neurotrophic factor (BDNF) levels [7]. BDNF plays a pivotal role in synaptic strength, plasticity, neuronal differentiation, maturation, and survival [19]. Depletion of BDNF is associated with deficits in dendritic spine density and neuronal loss [19,20]. Correspondingly, meta-analyses have revealed lower BDNF levels in BD patients when compared to both healthy individuals and those with unipolar depression [21,22]. Diminished BDNF levels have been observed in both manic and depressive states of BD, with lower BDNF levels linked to a more severe prognosis [10,21,22].

Risk Factors of Neuroinflammation

Both genetic and environmental factors have the potential to trigger neuroinflammation in BD. Genetic factors play a significant role in BD, with an estimated broad-sense heritability of approximately 67% [23]. However, despite genome-wide sequencing and analysis efforts, only 17-23% of the genetic contribution has been accounted for so far [24]. Even prior to the onset of illness, BD patients and their offspring exhibit an overexpression signature of inflammatory genes at the mRNA level [11]. A notable example is the polymorphisms of glycogen synthase kinase-3β (GSK-3β), an enzyme associated with proinflammatory responses by increasing proinflammatory cytokines IL-1β, IL-6, and TNF-α and lowering anti-inflammatory cytokines such as IL-10; GSK-3β is involved in many systemic neuro-inflammatory diseases such as Alzheimer's Disease, multiple sclerosis, and other mood disorders [25].

Sleep deprivation and stressful life events are widely recognized as triggers for manic episodes. Interestingly, these environmental factors are also associated with heightened levels of neuroinflammation [1]. The sympathetic release of norepinephrine prompts leukocyte mobilization and inflammation activation, a mechanism designed to preemptively guard against bacterial infection [26]. While not fully validated, it is posited that mood states might co-opt these pathways, promoting chronic inflammation maladaptively in BD. This relationship between mood and inflammation may also be bidirectional, as patients with systemic autoimmune diseases have an increased risk of developing BD [27]. Other chronic triggers of BD inflammation include dysregulated gut microbiota, unhealthy diet, smoking, substance/alcohol misuse, and sedentary lifestyles, all of which are also connected to heightened BD symptoms [28,29].

Sleep disturbance

Sleep plays a crucial role in regulating immune system functions and maintaining the balance of pro-inflammatory and anti-inflammatory factors [30]. In a large meta-analysis of 72 studies, sleep disturbance and restriction were associated with higher levels of CRP, though not IL-6 or TNF-α [31]. This relationship is bidirectional as increased inflammation during sickness

can also induce sleep [1]. BD patients frequently display disrupted sleep patterns, marked by an irregular sleep-wake rhythms, evening chronotype, melatonin secretion abnormalities, and response disturbances to social time cues [32]. Traveling across time zones can further disrupt circadian rhythms, with west-to-east travelers experiencing phase advance and east-to-west travelers experiencing phase delay. Strikingly, these circadian disruptions are linked to increased manic episode risk for west-to-east travelers and depressive episode risk for east-to-west travelers [33]. Similarly, "social jet lag", stemming from circadian rhythms disturbances due to late-night activities, can contribute to the development of mania [33]. Notably, insomnia and altered sleep architecture predict suicidal thoughts and behaviors in BD individuals [34]. As a result, the homeostatic role of sleep is integral to mood regulation in BD. Light therapy has also been demonstrated effective in mitigating depressive symptoms and synchronizing the internal clock in BD [35].

Glial activation

Microglia are the resident macrophages of the CNS and provide various functions that regulate cortical inhibitory neurons, forming new synapses, pruning weak synapses, and inducing neuronal apoptosis [36]. Jakobsson et al. showed that peripheral inflammation is associated with microglial chemoattractant molecules in CSF in euthymic BD patients [16]. In response to an inflammatory trigger, microglial cells become activated, enlarged, and phagocytic, releasing anti-inflammatory cytokines and neurotrophic factors that help prevent further harmful effects. In the context of chronic inflammation, prolonged activation of microglia dysregulates this process, which leads to the accumulation of pro-inflammatory cytokines and nitric oxide. This sustained activation of microglia contributes to excessive synaptic pruning and changes in the brain circuitry associated with mood and cognition in the prefrontal cortex, anterior cingulate cortex (ACC), hippocampus, and amygdala areas [37].

The involvement of microglia in BD has remained controversial as studies are still inconclusive [38]. Evidence from post-mortem studies indicates that patients with BD may exhibit microglia hyperactivation in the frontal cortices and hippocampal regions, suggesting the influence of these cells in the pathophysiology of the disorder [16,39]. Similarly, Rajkowska et al. found hypertrophy and changes to glial cell morphology in the prefrontal cortex, distinct from other neuropsychiatric conditions such as schizophrenia and MDD [40]. In the ACC, microglial density is increased with a decrease in microglial mRNA production [41,42]. Moreover, in vivo positron emission tomography (PET) scans have demonstrated microglial hyperactivation specifically in the hippocampus of individuals with BD when compared to healthy control subjects [43].

BD pathophysiology may also be associated with changes in other glial cells such as astrocytes and oligodendrocytes. These are seen in postmortem tissues; however, little is known about their specific roles. Markers for astrocytes have been shown to be decreased in the prefrontal cortex and with altered cell morphology in the ACC [38]. No changes were reported in the

amygdala or hippocampus [38]. One study observed decreased oligodendrocytes markers in the prefrontal cortex and mixed results were obtained in studies examining the hippocampus [38]. These findings are further summarized by Liu et al. in a systematic review [38]. However, a lack of studies and heterogenous results prevent definitive conclusions.

Mitochondrial dysfunction

Microglia, as phagocytic cells, are known to be robust sources of reactive oxygen species (ROS). The CNS has limited antioxidant capacity (despite consuming approximately 20% of the total oxygen levels in the body), requiring tight control of ROS levels. In BD, chronic inflammation is particularly exacerbated during manic states. Some individuals with BD exhibit mitochondrial dysfunction both peripherally and within the CNS [9]. Li et al. also demonstrated that mitochondrial DNA mutations such as 10398A are associated with impaired glucose utilization and higher fasting glucose in BD patients, even when compared to sibling controls [44]. Multiple studies have demonstrated increased levels of ROS markers in BD subjects compared to euthymic individuals, with higher levels observed in those experiencing manic and depressive episodes when compared to euthymic and control subjects [9]. Additionally, a meta-analysis by Brown et al. revealed elevated lipid peroxidation, as well as DNA/RNA damage, and a decreased total antioxidative capacity in individuals with BD [45]. Intriguingly, the markers indicative of oxidative stress levels increase over the course of BD during the euthymic period, reflecting an underlying pathophysiological state [46]. These findings suggest that the dysregulation of ROS and oxidative stress pathways contribute to the chronic inflammation observed in BD during manic states.

Kynurenine pathway

The activation of proinflammatory cytokines and the release of ROS induce the activation of the kynurenine pathway, which leads to the synthesis of quinolinic acid (QUIN) and/or kynurenic acid [47,48]. This process results in the depletion of serotonin and melatonin, which are crucial for sleep and mood regulation. Notably, QUIN can lead to glutamatergic excitatory overactivation of N-Methyl-D-Aspartate receptors (NMDAR), potentially contributing to neuronal loss and reduced hippocampal volume [49]. Additionally, QUIN can form toxic complexes with free iron ions, resulting in increased oxidative stress, and mitochondrial dysfunction [49]. These interactions contribute to the vicious cycle of chronic inflammation observed during manic states [50].

Neuroinflammation and Suicide for

Bipolar Disorder

Emerging evidence may indicate a possible connection between SB and the innate immune response. Suicidal subjects have been found to display elevated markers of inflammation in the prefrontal cortex and peripheral tissues, regardless of their primary diagnosis,

age, and gender [51]. Proinflammatory cytokines are associated to the transition from short-term mood changes to a chronic maladaptive depressive state by hindering mood normalization following adverse life events [1]. When looking at suicide risk among MDD patients, most studies have indicated a positive correlation between suicide risk and both peripheral and CSF levels of inflammatory markers such as CRP, IL-1β, IL-6, and TNF-α [51–55]. For SI, O'Donovan et al. also found that peripheral inflammatory markers such as IL-6 were increased while anti-inflammatory IL-10 was decreased [56]. Furthermore, decreased levels of neuroprotective cytokines have been observed in the plasma and cerebrospinal fluid of suicidal patients [51]. Additionally, studies examining the effects of medical interventions that artificially increase inflammatory markers, such as interferon treatment, have found an increased risk of depression and suicide [57,58]. [51] However, conclusions from these studies are limited due to their correlational nature and cannot be used to establish causality.

Though there are even fewer studies, evidence supporting the role of an inflammatory milieu could perhaps play a part in SB in BD as well. With regards to inflammatory markers, evidence finds that BD patients with a history of suicide attempts exhibited specifically increased serum levels of interleukin-6 (IL-6), but not TNF-α or IL-1β [59]. BD subjects with SI also have higher levels of IL-6R, even after controlling for cognitive factors [60]. CRP has shown mixed results [52,60]. These findings are further supported by studies of BD patients who completed suicide; limited evidence from postmortem studies on brain tissues and CSF from BD subjects who completed suicide show some evidence of increased neuroinflammation [61]. Again, caution is warranted as no causal conclusions can be drawn from a small number of correlational studies.

However, there is more evidence for the involvement of microglia in BD suicide. Numerous studies, primarily utilizing post-mortem examinations and PET imaging, have provided evidence linking microglia activation to SB [36,62–65]. Similar findings in two recent studies suggest an emerging pattern concerning microglial activation in BD suicide. Petrasch-Parwez et al. focused on microglia density in the anterior midcingulate cortex, an area associated with psychosis, while Brisch et al. examined density changes in the dorsal raphe nuclei, which play a role in serotonergic innervation of the forebrain [41,65]. Both studies found that BD patients had lower microglial density compared to the control group. However, it was observed that the microglial density increased back to control levels in BD patients who died by suicide. This suggests that while microglia levels may be correlated to decreased density in these areas in the chronic BD state, during the peri-suicide period microglial density subsequently increases due to activation or migratory patterns.

SB may not only be correlated to microglia density patterns but also to microglial activation in the brain. In a neuroimaging study, Qiu et al. found greater microglial activation in the prefrontal cortex, ACC, and insula, during depressive episodes when compared to control individuals [66]. Gene expression analyses in suicide victims have also revealed significant enrichment for microglia-related genes in the dorso-lateral prefrontal

cortex and hippocampus [67]. Naggan et al. demonstrated that BD subjects who died by suicide showed higher overall hippocampal microglia density, along with a reduction in the percentage of microglia expressing the lymphocyte activation gene 3 (LAG3) [68]. LAG3, involved in the antidepressant and neurogenesis-enhancing effects of electroconvulsive therapy, serves to decrease the activation of microglia when bound to major histocompatibility complex II (MHC II), which was previously found to be involved in BD and in suicide [69]. The study found that decreased LAG3 levels were correlated with increased density of microglia expressing MHC II, suggesting an activated microglial status in BD subjects who died by suicide [68]. These findings suggest that microglia localization and activation patterns may play a significant role in the development of suicidal vs non-suicidal tendencies in individuals with BD. Few studies on glial cells other than microglia have considered the impact of suicide on their measurements, but the neutrophil-lymphocyte ratio has been proposed as a reliable biomarker for assessing the risk of suicide attempts [70].

Dysfunction in the kynurenine and oxidative stress pathways may also be correlated with SB. Regardless of comorbid mood disorders, studies examining the CSF of individuals with prior SAs or SI have reported a three-fold increase in QUIN levels, which was correlated with the severity of SI [49]. Similarly, Brudin et al. showed that patients with SB have lower suppression of the kynurenine pathway via amino-β-carboxymuconate-semialdehyde-decarboxylase [48]. This lack of QUIN suppression persisted for at least two years after SAs [48]. However, while these studies point to an association between QUIN and suicide more broadly, the evidence regarding QUIN-mediated suicidal features specific to BD is less conclusive [50]. Sowa-Kucma et al. also found a correlation between higher levels of oxidative stress and both prior SAs and current SI in BD [71]. Taken together, these findings may support the hypothesis that there is a connection between suicidal behavior and the pathophysiology of neuroinflammation in BD. However, further studies are needed given the current lack of literature on the subject.

Potential Neuroinflammatory Modulators in Bipolar Disorder

Mood stabilizers

Lithium is currently the only drug that has been shown to reduce SB in addition to reducing the illness burden in BD subjects. Long-term treatment with lithium has demonstrated a significant reduction, ranging from 20% to 60%, in suicide attempts (SAs) and deaths among individuals with BD [72]. There is also a recent and growing body of evidence demonstrating its unique anti-inflammatory properties, which may be linked to its effects in reducing SB. Lithium exhibits anti-inflammatory activity by inhibiting the synthesis of IL-1β, TNF-α, and cyclooxygenase-2 while stimulating the production of IL-2 and IL-10 [9]. Studies have shown that lithium inhibits microglial activation and exerts

anti-inflammatory effects by inhibiting GSK-3β which upregulates the production of the anti-inflammatory cytokine IL-10 and reduces proinflammatory cytokines [73]. Polymorphisms in the gene encoding GSK-3β have been found to influence the response to lithium, further emphasizing GSK-3β as a promising therapeutic target for BD [8]. Madireddy and colleagues recently summarized that BD subjects who clinically responded to lithium exhibited notably lower levels of oxidative stress when compared to non-responders, an effect that is not observed in healthy individuals given lithium [9]. Together, these findings highlight the need for future study into tailored treatments of BD subjects with neuroinflammation.

The anti-inflammatory effects of other mood stabilizers have not been studied adequately enough to draw conclusions [74]. Only one randomized control trial has reported on the anti-inflammatory effects of lamotrigine compared to valproic acid [75]. After three months of treatment in BD patients with depression, serum levels of IL-1β and IL-6 as well as microglial chemoattractants were lower in both groups, however, cytokine levels were higher in the lamotrigine group [75]. Two additional studies examined the effects of valproic acid alone, with both studies finding insignificant improvement in inflammatory markers [76,77]. We found no studies examining the effects of carbamazepine. Further studies are needed to explore the anti-inflammatory effects of these mood stabilizers.

Antipsychotics

There are no studies examining the anti-inflammatory effects of antipsychotics in BD patients. However, there is some theoretical basis that the potential application as GSK3β can be inhibited exogenously by olanzapine [78]. Indeed, a recent review by Patel et al. showed broad anti-inflammatory effects in subjects with schizophrenia and first-episode psychosis using risperidone, aripiprazole, and olanzapine [79]. For clozapine use in schizophrenia, a study found that CRP levels increased six-fold in the acute initiation phase but returned to baseline after long-term use [80]. Until further studies examine these effects for BD, their effects remain unclear. The neuroinflammatory modulation effects of known BD medications are summarized in Table 1.

Other potential neuroinflammatory modulators

Other modulators of BD inflammation merit further evaluation for potential augmentative treatments; however, the data are less robust. Meta-analyses of anti-inflammatory therapies such as aspirin, celecoxib, infliximab, N-acetylcysteine (NAC), omega-3 fatty acids, and pioglitazone have shown effectiveness in reducing both manic and depressive symptoms in BD [59,81]. Aspirin has demonstrated potential as a co-adjuvant therapy in reducing lithium doses and enhancing the effects of first-line antimanic drugs [8]. Interestingly, a population study in Denmark also revealed a reduced incidence of BD with the use of low-dose aspirin [82]. Minocycline, known for its microglia-inhibiting properties and ability to reduce TNF-α production, has

been used off-label since 1996 as an adjunctive treatment of BD [81]. Studies have also reported significant antidepressant effects of minocycline in bipolar depression, particularly in subjects with high baseline levels of IL-6 [83,84].

Preliminary studies of ketamine have also begun in BD populations. Ketamine is a dissociative anesthetic which primarily acts as a NMDAR antagonist. By modulating glutamate excitotoxicity, ketamine has also shown limited anti-neuroinflammatory effects with associated decreases in IL-6 and TNF-α in the brain and reducing QUIN production [85–87]. Ketamine received FDA approval for treatment-resistant unipolar MDD in 2019 [88]. Overall, ketamine has demonstrated weak efficacy in treating BD depression [89]. A limited number of studies have also explored the use of ketamine for treating depression or SB in BD subjects. The current body of evidence demonstrates a rapid but transient reduction in suicidal thoughts, leading to ongoing evaluations of ketamine therapy for SI in BD subjects [90]. The largest double-blind, placebo-control trial to date found that BD subjects exhibited the largest acute reduction in SI of any mental health condition with an odds ratio of 14.1 and no mood-switching events [91]. A trial examining six weekly infusions observed both an acute reduction in SI as well as further reductions in SI with repeated doses [92]. However, caution is warranted as one study showed increased SI in two of its subjects [93]. Any conclusions regarding the efficacy of ketamine in SB for BD patients is premature as these studies employed small sample sizes with conflicting conclusions. Given the insufficient number of trials, further study is required to inform future clinical practices.

However, other inflammatory modulators such as adjunctive infliximab, a TNF-α inhibitor, have not demonstrated antidepressant effects [94]. These findings underscore the need for further study of this complex interplay: simply reducing neuro-inflammatory markers is not the sole solution to reduce BD depression and SB.

The emerging body of evidence suggests a link between neuroinflammation and SB for a subset of BD subjects, but other confounding variables also blur the results.

Lifestyle changes

Subjects experiencing severe BD depression may exhibit increased inflammatory markers due to pro-inflammatory lifestyle factors. Many BD patients have a limited ability to engage in positive lifestyle changes that decrease chronic stress and inflammation, such as consistent psychotherapy, exercise, and a healthy diet [95]. This, in turn, may lead to a compounding cycle. Though metabolic factors have not been associated with BD suicide, those who have an unhealthy diet, smoke, misuse substances/alcohol, and lead a sedentary lifestyle tend to experience more severe symptoms [28,96]. Several randomized control trials and longitudinal observational studies have examined the effects of multimodal lifestyle interventions on mood or health for BD patients (Table 2). However, all of these studies are limited by small sample sizes and fail to explore their effects on inflammation (or do so in a very limited way). For example, in their study on the effects of lifestyle coaching in BD patients, only Frank et al. examined changes in serum inflammatory markers (CRP and IL-6) due to lifestyle interventions and found no changes [97]. However, higher baseline CRP, indicating poorer physical health, was associated with a greater reduction in BMI [97]. Further study is needed to assess the effects of additional lifestyle interventions such as exercise, diet, therapy, and sleep-wake cycle interventions on inflammation in BD patients. These lifestyle changes for BD patients, while potentially augmentative, should always be implemented in addition to evidence-based pharmacotherapy under the supervision of a qualified medical professional. Lifestyle changes alone cannot replace evidence-based mood stabilizing medications, particularly for those experiencing more severe BD symptoms.

Table 1. Potential neuroinflammatory modulators of medications used to treat bipolar disorder.

Intervention	Population	Method	Results	References
Lithium	n = 32 euthymic BD	Cross sectional study of TNF-α levels with longitudinal clinical response	Lower TNF-α are associated with better clinical response to lithium and lithium monotherapy vs medication free controls	Guloksuz et al. 2012 [98]
Lithium	n= 267 BD	Longitudinal assessment in severity of symptoms and episodes for 18 mo.	Negative correlation between duration of lithium treatment and CRP levels	Queissner et al. 2021
Lamotrigine, valproate	n=170 BD or MDD	RCT emotional state and cognitive function for 2 mo.	Decreased macrophage MIF, IL-1β, and IL-6 for both drugs. Increased cytokines in lamotrigine vs valproate.	Shi et al. 2018 [75]
Risperidone, olanzapine, aripiprazole	n= 27 schizophrenia, drug naive	Longitudinal study for three months	Reduction in plasma levels of IL-1β, IL-6, and IL-17A	Subbanna et al. 2020 [99]

Notes: Bipolar Disorder (BD), C-Reactive Protein (CRP), Major Depressive Disorder (MDD), Migration Inhibitory Factor (MIF), Randomized Control Trial (RCT), Tumor Necrosis Factor-alpha (TNF-α).

Table 2. Effects of lifestyle interventions for patients with bipolar disorder.

Lifestyle change	Population	Method	Results: Difference in patients (vs. controls) at baseline, or patients pre- and post-treatment	References
Lifestyle Coaching	n=58 BD with intervention n=56 BD control	RCT for six months of lifestyle coaching and medical monitoring	Reduction in BMI; no change in CRP or IL-6; CRP, IL-6, sleep, and cholesterol modulate rate of BMI decrease	Frank et al. 2015 [97]
Nutrition and physical activity intervention	n=26 BD with intervention n=24 BD control	RCT for five months of nutrition and weekly fitness training, six months of follow up	Significant and lasting decrease in BMI in women; no effect for cardiovascular and metabolic parameters	Gillhoff et al. 2015 [100]
Management of chronic diseases	n=57 BD with management n=59 BD control	RCT for 24 months of four group management sessions	Reduced systolic and diastolic blood pressure; reduced manic symptoms; no changes in cholesterol, triglycerides, or BMI	Kilbourne et al. 2013 [101]
Physical Activity	n=145 BD patients	Longitudinal assessment of physical activity for 20 weeks	Improvement in social and occupational functioning; subjective improvement in quality of life	Ashton et al. 2020 [28]
Mindfulness Therapy	n=30 BD patients	Longitudinal mindfulness therapy sessions over 11 weeks	Reduction of depressive symptoms with a moderate effect size; improvement of overall well-being	Hanssen et al. 2019 [102]
Light Therapy	N=259 BD patients	Meta-analysis of seven RCTs	Improvement in depression rating and clinical response; no difference in affective switching	Lam et al. 2020 [35]

Notes: Bipolar Disorder (BD); Body Mass Index (BMI); C-Reactive Protein (CRP); Randomized Control Trial (RCT).

Conclusion

Due to altered neural connections in mood regulation and impulsivity, BD has the highest burden of suicidality of any neuropsychiatric disorder at the individual level. With declining life expectancy due to SB and a higher risk of chronic diseases, understanding the underlying drivers in BD is of increasing importance. As the disorder is defined by a constellation of clinical signs and symptoms rather than a uniform biological mechanism, BD pathophysiology has profound individual variation. Whether causative or correlational, emerging data suggests that neuroinflammation is linked to BD progression and SB for a significant subset of individuals. However, it is crucial to acknowledge the presence of considerable heterogeneity across multiple studies, underscoring the complexity of this issue. As such, all findings should be approached with caution to ensure a comprehensive understanding of the relationship between neuroinflammation and BD. Further research and exploration are essential to gain deeper insights into this association.

This study possesses significant limitations that contextualize our review. None of the human studies we have examined above showed causation between inflammatory states and mental health symptoms, only association. This study is also limited as we did not consider non-English articles and unpublished data, introducing a possibility of publication bias. Although a few studies have considered the impact of suicide on their measurements, many studies have not included measures of SI, SA, or completed suicide in their statistical analysis, which represent another limitation. Of the studies that did examine differences for BD patients who completed suicide, the samples came from postmortem brains and there was no record of the use of specific drugs before death, which could influence the expression of proteins and inflammatory markers. Heterogeneity in brain bank analyses post-suicide introduces several other confounding factors, including diagnostic methods, time to storage, age, lifestyle choices, and many other variables. The majority of studies made no delineation between the different subtypes of bipolar disorder which could provide helpful distinctions in the neuroinflammatory relationship. Addressing these areas of limited research and limitations presents an opportunity to differentiate patients who may respond better to targeted anti-inflammatory therapies. Moreover, addressing excess inflammation may produce improvements in functional and cognitive status.

Lithium, as an established therapeutic intervention, has shown promise in reducing neuroinflammation and addressing suicide risk in BD. On the other hand, emerging therapies like ketamine, aspirin, and minocycline also exhibit potential in managing BD symptoms by targeting neuroinflammation. However, it is essential to recognize that these emerging therapies require more extensive data and research in order to fully comprehend the efficacy and safety of these novel therapeutic approaches. Therefore, the treatment of BD, especially for those at high risk of suicide, must be undertaken in a careful, patient-centered manner. We are hopeful that further research in neuroinflammation

holds promise for enhancing our understanding of BD pathophysiology and that it will develop more effective life-saving treatments.

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Conflicts of interest

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This study did not require ethical approval because no individual information was used.

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The Therapeutic Effects and Prospects of Light Therapy for Depression

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Abstract: *Background/purpose:* With advances in medical technology, light therapy has attracted increasing attention as a non-drug treatment for depression. *Methods of study:* We conducted a scoping review to understand the efficacy and uses of light therapy as an intervention for depression. *Results:* Light therapy exhibits good results for seasonal affective disorder and non-seasonal affective disorder. Light therapy can simulate sunshine duration and alleviate the symptoms of seasonal affective disorder. It can also regulate the circadian rhythm to alleviate the symptoms of non-seasonal affective disorder. *Conclusions:* Light therapy has many applications as a non-drug treatment. Light therapy is an effective adjuvant treatment for depression patients as it can achieve therapeutic effects and improve patients' quality of life. The introduction of human factors and ergonomics and advanced optical techniques can allow light therapy to play dual roles of alleviating injury and treatment in depression and other psychological disorders.

Keywords: light therapy, depression, light-emitting diode, seasonal affective disorder, dementia.

Introduction

Depression is a common psychiatric disorder, and 4.4% (2017) to 5% (2023) of people suffer from depression globally [1]. The prevalence of depression in women is 5.1%, which is higher than in men (3.6%), and prevalence is higher in elderly people: In the 55-to-74-years-old age group, the prevalence of depression in women increases to 7.5%, which is still higher than in men (5.5%) [2].

Each year, the usage of artificial lighting increases at a rate of 3–6% [3], and the areas where artificial lighting are used increases at a rate of more than 2% [4]. The 2017 Nobel Prize in Physiology or Medicine was awarded to Jeffrey Hall, Michael Rosbash, and Michael Young for their discoveries of molecular mechanisms that control circadian rhythms. They discovered three genes that control the circadian rhythm in organisms, which they called the period, timeless, and double time genes [5]. Their research found that the circadian rhythm plays an important role in sleep. How much light dosage needs to be provided? Intelligent and precise lighting has become a notable form of precision health intervention. Good sleep quality can improve work and learning efficiency. Studies on lighting color temperature have found that a high color temperature will inhibit melatonin secretion and increase serotonin, resulting in hyperactivity, whereas a low color temperature will result in greater pleasure [6].

The results of a study by Chongqing University showed that using white light LED with a color temperature of 6,000 K from 9 am to 12 pm and gradually increasing light intensity to 10,000 lux can achieve 0.99 inhibition of melatonin. The vision and psychological subjectivity of students will reach an optimal state under such lighting conditions. It is recommended that warm white light LED with a color temperature of 2,700 K and light intensity of 300 lux be used at rest. At such lighting conditions, the melatonin inhibition rate is lower, at around 0.59. Such lighting conditions can help in physical and mental relaxation [7]. With regard to light therapy, a large volume of studies have proved that light therapy can decrease stress and depression and delay senile dementia [8-11]. We aimed to explore the following issues: 1.) influence factors of light in light therapy for depression; 2.) proposed mechanisms underlying the therapeutic effects of light therapy in depression; 3.) evidence regarding the effectiveness of light therapy in treating depression; 4.) the current state of knowledge and research gaps.

Methods

We conducted this systematic review. We searched PubMed, Web of Science, and Google Scholar, from their inceptions to June. 1, 2023 for original research articles that examined the association of light therapy with depression; The search keywords will include "light therapy", "phototherapy", "bright light therapy", "depression", "major depressive disorder" and related terms. Additionally, the inclusion criteria for study selection will be as follows:1.) studies focusing on the application of light therapy for the treatment of depression; 2.) original research articles, systematic

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reviews, and meta-analyses; 3.) studies conducted on human participants or mammals; 4.) studies published in peer-reviewed journals; 5.) studies available in English or Chinese.

Diagnosis of Depression

Prevalence of depression

In 2002, a study on 20,000 Taiwanese subjects by the Health Promotion Administration of Taiwan's Ministry of Health and Welfare found that 8.9% of people aged 15 years and above had moderate depression and 5.2% had severe depression, which were far higher than the 2.2% estimate by the World Health Organization. There were more cases of severe depression with an increase in age: 6.8% in those aged 15–17 years old and 8.4% in those 65 and above years old. The incidence of depression in women (10.9%) is 1.8 times that of men. It is estimated that there are more than 1 million depression patients in Taiwan. However, the consultation rate for depression is very low, at about 2.3% [12]. Although psychiatric and pharmacological treatments for depression are available, more than 75% of those affected by psychiatric disorders in low- and middle-income countries do not undergo treatment [1].

Depression symptoms

Depression is characterized by persistent sadness and lack of interest in activities that were deemed beneficial or pleasurable in the past, thereby interfering with sleep and appetite, and fatigue and lack of attention are common manifestations. These above negative manifestations not only result in mental harm but also cause physical harm and increases the financial burden in global medical costs [13]. Depression differs from emotional fluctuations caused by stress in daily life, and the long-term effects and repeated attacks of depression affect the work and lives of patients [1].

Etiology of depression

The cause of depression is a complex interaction between social, psychological, and biological factors. An unfortunate childhood, loss, and unemployment can also promote the development of depression [1]. With regard to biological factors, depression is an imbalance of chemicals inside the brain, such as serotonin, norepinephrine, and dopamine. These chemicals are responsible for affecting regions of emotional regulation in the brain, including the amygdala, thalamus, and hippocampus, thereby causing various psychiatric symptoms [14]. Depression shows significant familial inheritance, and the probability of a monozygotic twin developing depression when his or her sibling has depression is 70%. People with low self-esteem, who tend to be affected by stress, or who are pessimistic are prone to depression. Long-term exposure to violence, neglect, abuse, or poverty causes some people to be prone to depression [15].

Types of depression

The fifth edition of the Diagnostic and Statistical Manual of Mental Disorder (DSM-5), states that depression is polymorphic and classifies it into the following types based on presentation and influencing factors: 1.) persistent depressive disorder or dysthymia, in which the patient's depression persists for at least two years; 2.) major depressive disorder, in which the depressive symptoms of a patient severely affect life for more than two weeks; 3.) premenstrual dysphoric disorder, in which physical and mental discomfort occurs in premenstrual women, such as feeling low and irritability; 4.) postpartum depression, in which severe depressive symptoms occur during or after pregnancy in women and the patient feels extreme fatigue, sadness, or anxiety; 5.) adjustment disorders, which are a form of depression caused by stress and emotional or behavioral symptoms, occurring within three months after encountering the source of stress, in which patients usually recover within half a year after the source of stress disappears; and 6.) seasonal affective disorder (SAD), which tends to occur during winter in regions with less sunlight and high latitude, in which patients usually are affected every year.

Bipolar disorder is also known as manic depression but is not actually depression; nonetheless, the depressive symptoms of a depressive episode in a patient with bipolar disorder are sometimes difficult to differentiate from those in a patient with unipolar depression. Therefore, bipolar disorder is often included in studies with topics related to depression [14].

The Mechanism of Light Therapy

Basic principle and types of light therapy

Light therapy uses sunlight or artificial light sources of specific wavelength to carry out physical therapy so that patients or cases can resume normal circadian rhythm. Light therapy is one of the treatments for SAD in clinical standard guidelines as SAD is a classical disease caused by a dysregulated biological clock due to insufficient sunlight. This is because insufficient daylight hours and light intensity causes a lack of diurnal inhibition of melatonin and insufficient serotonin secretion, resulting in a disorderly circadian rhythm [16]. The treatment method is to irradiate depression patients with strong light to decrease serotonin reabsorption by decreasing the in vivo binding of paroxetine and imipramine, which greatly increases the in vivo levels of serotonin and inhibits the release of diurnal melatonin so that there is a high level of melatonin rebound at night, thereby regulating the sleep cycle, and promoting the activity of the hypothalamus-pituitary gland-adrenal cortex (HPA) to improve depressive symptoms [17]. Light exposure can increase nocturnal parasympathetic nervous activity [13,18]. The parasympathetic nervous system acts as a brake to slow down the body's operation rhythm and increases cerebral blood circulation and metabolism, thereby increasing glutamate and gamma-hydroxybutyric acid (GABA) to promote deep sleep [13]. When the nocturnal parasympathetic nervous system is inhibited, sympathetic nervous activity will increase greatly, causing systemic burden and damage [19].

Regulatory variables of light therapy

Light spectrum distribution

Early studies showed that the optimal wavelength for inhibiting melatonin is 509 nm, and this wavelength is close to the maximum response wavelength of scotopic vision [20]. Further studies by Zaidi et al. found that rod cells and cone cells are not light sensors that inhibit melatonin [21]. A new study found that 446–477 nm light is more effective at inhibiting nocturnal melatonin secretion than light with a longer wavelength. It is worth noting that this wavelength interval is extremely close to the maximum response wavelength of retinal ganglion cells [22].

The study of Wright et al. found that when subjects were irradiated with 470 nm, 497 nm, 525 nm, 595 nm, and 660 nm LED light at a specific time period every day for 40–50 minutes, 470 nm blue light LED shows maximum melatonin inhibition rate [23]. The study of Lu et al. found that when 468 nm, 457 nm, and 453 nm blue light LED were used to irradiate healthy subjects, the work efficiency of subjects was the highest under a peak wavelength of 468 nm blue light. At the same time, the subjects did not feel tired easily [24].

At present, the light intensity and color temperature of LED artificial lighting can be adjusted. However, although LED irradiance can regulate light parameters based on physiological rhythm, both physiological and psychological needs cannot be simultaneously satisfied at the same time. The specific nodes are still unclear, and the number of nodes is also insufficient. The International Commission on Illumination CIE S 026 standards provided a definition for the circadian action factor (CAF) and pointed out that the main light spectral waveband that affects the circadian rhythm is 480 nm blue light. Therefore, combination with blue light in regulating nocturnal illumination environment is an important consideration for affecting physical and mental health [25].

Light intensity

Melatonin is highly sensitive to light intensity, and different organisms have different sensitivities to light intensity. Using rats as an example, their pineal glands are extremely sensitive to light intensity. When light intensity is lower than 10 lux, N-acetyltransferase activity is decreased by 50% [26]. In contrast, monkeys require higher light intensity (around 500 to 600 lux) to effectively inhibit melatonin secretion [27]. Compared with other mammals, humans require higher light intensity to effectively inhibit melatonin secretion [28].

Lewy et al. conducted a study in which subjects were exposed to different light conditions from 2 am to 4 am. They used 500 lux and 2,500 lux to irradiate subjects for two hours. The study results showed that melatonin concentration quickly decreased within 10 to 20 minutes, reached the lowest level within 1 hour, and was maintained at a steady level in the 2,500 lux group. When subjects entered a dark environment for 42 minutes, melatonin concentration quickly increased to a level that was even higher than before light exposure. In addition, 1,500 lux also had similar effects as 2,500 lux irradiances, as it could decrease melatonin concentration by 50%. However, under 500 lux irradiances, the

melatonin concentration of subjects seemed to not change and concentration not only did not increase but slightly decreased after subjects entered a dark environment [29]. McIntyre conducted another study to examine the effects of five different light intensities on the melatonin inhibition rate. They irradiated healthy subjects with 3,000 lux, 1,000 lux, 500 lux, 350 lux, and 200 lux at midnight. After one hour of irradiance, the study results showed that the melatonin inhibition rates were 71%, 67%, 44%, 38%, and 16%, respectively [30].

Irradiance duration

The above findings showed that melatonin inhibition is intimately associated with light intensity. The higher the light intensity, the shorter the time needed to inhibit melatonin secretion. The timing of irradiance should also be considered aside from irradiance duration. The irradiance timing should also differ for different patients. For example, we found from studies that 10,000 lux high light intensity light therapy in SAD patients or those with an owl sleep pattern after waking up could improve depressive emotions and sleep quality. In contrast, it is recommended that irradiance be performed in the evening for patients with lark sleep patterns. With regard to irradiance duration, by comparison of the results of Lewy and McIntyre, it could be observed that the melatonin inhibition rate differs under the same light intensity. This may be due to differences in irradiance duration used in the two studies, and differences in irradiance duration may be an important cause affecting melatonin inhibition [31].

Melatonin concentration is relatively low in the human body in day time. However, melatonin is rapidly secreted at midnight and peaks between 2 am and 3 am. At this time period, the human body is at its most sensitive to interference; that is, irradiance affects melatonin secretion [31]. If we are able to understand the effects of light intensity, illuminance, and light spectrum on melatonin and serotonin, we can understand that light therapy has good therapeutic effects for depression [31]. If intelligent control of LED lights with adjustable illuminance and color temperature is carried out, lighting with different therapeutic effects can be controlled based on the patient's needs to achieve depression prevention and treatment under specific lighting conditions, and this will be a major breakthrough in physical therapy in the future [17].

Biological effects of light therapy on depression

Nocturnal melatonin concentration in depression patients has been proven to be lower than in normal people, and reduced secreted melatonin concentration in the human body may cause depression. The main mechanism is decreased serotonin in the brain, resulting in decreased melatonin secretions. Insufficient melatonin secretion may cause SAD and endogenous depression symptoms [16,17]. Melatonin can regulate the disorderly biological clock in depression, improve sleep quality, and further alleviate depressive symptoms [32]. Light therapy can decrease melatonin secreted by the pineal gland and promote serotonin release. This not only improves sleep quality but also decreases the occurrence of depression. This has been proven repeatedly in clinical practice, and

light therapy has become a standard option for treating depression [17].

Intrinsically photosensitive retinal ganglion cells (ipRGCs) are mainly located on the retina. When a beam of light enters ipRGCs, it transmits neural signals to the suprachiasmatic nucleus (SCN), which connects to the pineal gland through a specific neural network, resulting in the secretion of melatonin. [33]. Higher illuminance results in more significant melatonin inhibition. The lower the illuminance, the longer the time required for melatonin inhibition [24,31]. The relationship between melatonin and external light is not only influenced by the intensity of light but also by the wavelength distribution of the spectrum. Blue light with wavelengths around 445 to 480 nm is more effective in suppressing the secretion of melatonin during the night compared to longer-wavelength light. Additionally, research showed that light with a peak around 500 nm on the spectrum has the most significant inhibition of melatonin.

Neuroregulatory mechanism of light therapy and depression

When a light beam enters retinal ganglion cells in the human eye, light energy is converted into nerve impulses through the melanopsin. The nerve impulses reach the SCN through the retinohypothalamic tract. The SCN is located at the hypothalamus on top of the optic chiasm. This center controls the neuroendocrine, the body temperature, the blood pressure, blood glucose, the autonomic nervous system, activity and rest, and the sleep cycle [34,35]. The SCN tends to be affected by aging and is characterized by decreased light sensitivity in the eyes and decreased light transmission in the retina. This is due to a decreased pupil diameter and yellowing of the lens, thereby providing an explanation for why people with insufficient sunlight and elderly people are prone to a dysregulated circadian rhythm, resulting in sleep disorders and senile depression [36].

The biological clock is located in the SCN in the thalamus of the brain and is an important regulatory center that regulates the intrinsic biological rhythm in humans. In the absence of external stimuli such as light, social activities, and clocks, the human circadian rhythm (or sleep–wake rhythm) is around 24 hours. However, the effects and regulation by external stimuli (known as exogenous rhythm) causes phase-response curve changes in our internal clock. Specifically, external stimuli cause our clock to be phase-advanced or phase-delayed. This means that the human circadian rhythm may be advanced or delayed by a period of time when an exogenous rhythm acts on the internal clock. This phase response curve displacement is affected by external stimuli, such as light, food intake, and social activities. Therefore, our internal clock and circadian rhythm are jointly regulated by intrinsic and extrinsic factors, allowing us to adapt to different environmental conditions and lifestyle rhythm [37].

When the internal biological clock undergoes phase advance, people may feel tired at night and even wake up before dawn. Conversely, when phase delay occurs, people may become night owls and can only sleep before daybreak, feel sleepy throughout the day and find it difficult to work. To change such abnormal

phase displacement, light therapy can be employed and an artificial lighting environment created to adjust the circadian rhythm. Light therapy uses artificial lighting to correct abnormal phase displacement. This treatment can help people restore a normal biological clock, allowing their neurological function to recover, and enhance and excite their mental state, thereby achieving a brighter and more cheerful life [37].

Clinical Application

Therapeutic effects and safety of light therapy in depression

Irradiance can activate molecules and cells in the body, such as immune cells, inflammatory mediators, and bone marrow-derived stem cells. These cells secrete neural growth factors or brain-derived neurotrophic factor to protect neuronal function. Insufficient irradiance impairs neural repair, resulting in disorderly behavior in the brain and anxiety and depression [38]. Irradiance can increase parasympathetic nervous activity to achieve relaxation and promote blood flow in the brain, and improve cognitive function [39]. The mechanism is that external light stimulates dopaminergic neurons in the ventral tegmental area in the brain, producing large amounts of hyperpolarization-activated currents, which increases current in potassium channels, thereby reversing depressive symptoms.

In previous studies, provision of sufficient morning light of 2,500 lux for 60 minutes in the morning from 9 am to 10 am on Monday to Friday for four weeks increased sleep efficiency by 41.9%, increased nighttime sleep time by 141 minutes, decreased night waking time by 116 minutes, resulted in an advance in sleep timing by 60 minutes, and delayed waking up by 57 minutes. After eight weeks of irradiance, sleep efficiency increased by 31.7%, sleep duration increased by 35 minutes, night waking decreased by 108 minutes and resulted in an advance in sleep timing by 84 minutes [19]. Similar irradiance intervention for four weeks decreased neuropsychiatric symptoms by 65% and improved cognitive function by 19%. After eight weeks, neuropsychiatric symptoms decreased by at least 78%, and cognitive function increased by 28%, which decreased psychiatric symptoms and improved cognitive function [17] and nocturnal parasympathetic nervous activity [18]. Irradiance in subjects with low physical activity level and severe dementia can improve sleep, neuropsychiatric symptoms, cognitive function, and parasympathetic nervous activity.

Indications for light therapy

The following sections will describe the study results concerning seasonal depression, non-seasonal depression, recurrent depression, chronic depression, pregnant women, chronic depression, anxiety, insomnia patients, and dementia.

Seasonal depression

Seasonal depression tends to occur in autumn and winter with less sunlight and cold temperatures or high-

latitude northern European and North American regions. This is mainly due to insufficient sunlight. Symptoms usually alleviate as spring comes when sunshine hours increase. According to epidemiological statistics, 80% of patients are women. The mean age of onset is 40 years old and half of patients have first degree relatives with a history of depression or other psychiatric disorders. Patients significantly feel better and have a positive attitude toward surrounding events after exposure to sunlight or artificial lighting. At the same time, their physical strength tends to improve when symptoms are alleviated, sleepiness decreases, excessive eating and cravings for sweets decrease. Since 1984, Rosenthal et al. have proved that irradiance with 2,500 lux can effectively alleviate depressive emotions in SAD patients. After extensive research and multiple clinical experiences, light therapy has become one of the non-drug clinical guidelines for treating SAD [40].

Non-Seasonal depression

Even non-SAD shows seasonal presentation. Terman conducted a statistical analysis of a large volume of medical records and found that recurrent or chronic depression occurs randomly in one year, but symptoms are more severe in winter [41]. Lam recruited non-seasonal depression patients and divided them into four groups for study: Group 1 received experimental group light therapy and a placebo, Group 2 received control group light therapy and antidepressants, Group 3 received control group light therapy and a placebo, and Group 4 received experimental group light therapy and antidepressants. The results showed that eight weeks of intervention could significantly alleviate depressive symptoms in Groups 1 and 4, showing that light therapy alone or combined with drugs can effectively treat non-seasonal depression [42].

Recurrent depression

With regard to recurrent depression, Wirz et al. conducted a study in which 29 patients underwent three weeks of light therapy (light intensity: 5,000 lux, duration: two hours every day). The study results showed that the depression scale score increased by 64.1%, and there was significant improvement in depression [43].

Chronic depression

Goel et al. conducted a study on chronic depression. In their study, patients received 10,000 lux irradiation every morning for one hour. Patients were treated for five weeks. The study results showed that depression improved by 50% compared with the control group [44]. Golden et al. and Pail et al. also conducted related studies and obtained identical conclusions [10,45].

Pregnant women and breastfeeding mothers

Light therapy can improve sleep and alleviate depressive symptoms in patients experiencing low mood, lack of energy during the day, and insomnia, who are not suitable for drug treatment, such as pregnant women and breastfeeding mothers. However, light therapy is not suitable for such patients if symptoms are severe. Donmez treated pregnant or first year postpartum patients who were diagnosed with severe depression according to the DSM-5 with light therapy (10,000 lux) for 45 minutes at a fixed time point every morning and compared with the control group who received dimmer light therapy (<500 lux). The Montgomery–Åsberg Depression Rating Scale (MADRS) was used for subjective evaluation. The MADRS results showed that significant differences existed in the response rate and remission rate between the experimental group and control group, which were 75% and 18.2%, respectively (p = 0.006), and 41.7% and 0%, respectively (p = 0.016). They found that high intensity light therapy could effectively decrease depressive symptoms during or after pregnancy, without causing severe side effects in patients [46].

Chronic depression, anxiety, and insomnia patients

Although non-drug therapy is known to be a mainstream treatment for chronic insomnia patients [47], light therapy has also become an accepted treatment. Light therapy is recommended for patients with stable symptoms after adjustments to work/rest and increased exercise but who still suffer from daytime fatigue or sedative dependence. The 2017 guidelines published by the European Sleep Research Society pointed out that light therapy is mostly used at present as adjuvant treatment for chronic insomnia [47,48]. This is because previous studies on light therapy reported that its effectiveness is inconsistent. Meta-analysis showed that light therapy could only increase total sleep duration by 15 to 25 minutes and does not reach 30 minutes. However, careful perusal of various papers shows that most papers used light boxes that are directly placed 60 to 80 cm in front of patients. In addition, these light boxes are extremely bright, with most studies using a light intensity of 2,000 lux and above. Humans are known to naturally avoid very bright light, thereby resulting in inconsistent results. Hence, there is a need to address these problems in the future.

Dementia

A systematic review and meta-analysis examined the reasons for inconsistent results of studies on bright white light treatment in senile dementia patients [49]. In the past, the reason for inconsistency was believed to be due to dementia severity and type, resulting in differences in results between different studies [50,51]. A meta-analysis of eight studies published from 2001 to 2017 was carried out. The results showed that bright white light treatment was effective compared with control treatment and that this result was significant (effect size d = 0.422). In addition, the therapeutic effects of white light (d = 0.460) and blue light (d = 0.464) were similar. Onega examined the effects of bright white light on depression and restlessness in elderly dementia patients [52]. The results showed that significant lighting condition × test time interaction was observed in the measurement data of seven types of depression and anxiety. Further analysis found that there were significant changes in depression and anxiety measurements in the bright white light group at T1 (before intervention) and T2 (after eight weeks); no significant change was observed in depression measurements, but significant changes were observed in anxiety measurement after eight weeks in the control

group (low light intensity).

Light therapy could alleviate symptoms and result in positive attitudes and greater vitality in depression patients. The symptoms of atypical depression patients also improves. During the autumn and winter of high latitude countries, longer nights result in greater depression in patients, and light therapy is a standard treatment [16]. People who travel over time zones or undertake long-distance travel also need to regulate their biological clock. Light therapy can alleviate jet lag and is a non-invasive treatment besides oral melatonin.

Pros and Cons of Light Therapy

Light therapy is a non-drug method for treating depression and other emotional disorders. This treatment often involves placing patients in special light boxes that emit blue light to simulate natural light. This stimulates the brain to produce more serotonin and other neurotransmitters, thereby alleviating the patient's symptoms.

Pros

Non-invasive treatment: Light therapy does not involve surgery, injection, and other invasive treatments. Some antidepressants may cause drug dependence in patients, and withdrawal symptoms may occur after treatment discontinuation; however, light therapy does not have accumulation effects and is therefore safer than drug therapy.

Fewer side effects: Light therapy usually does not cause severe side effects, and treatment can be completed within a short period of time.

Good complementation: Light therapy can be combined with drug therapy and psychological treatment to improve treatment outcomes.

Good results: Studies show that light therapy has better results for severe dementia [17].

Cons

High cost: Compared with other drug treatments, light therapy costs higher as specialized equipment is required. However, light therapy is cheaper than psychological treatment.

Time-consuming: Patients are required to sit in a light box or in front of a lamp for light therapy every day, and this usually takes 30 minutes to 1 hour every day. However, psychological treatment lasts longer, patients require more visits and interactions with professionals, and patients need to invest more time and effort.

Small suitable population: Light therapy is mainly suitable for SAD and other light-related depressive symptoms, and more clinical experience is required to determine its effects in other types of depression.

Future Outlook

Developmental trends and prospects of light therapy

In traditional light therapy, cases receive light therapy at a fixed time point, fixed duration, and with a fixed light box, such as 30–60 minutes in the morning with a light intensity of 500–10,000 lux. Existing commercially available light boxes usually only provide a fixed light intensity, color temperature, and spectrum. However, effective bright light (>2,000 lux) tends to cause avoidance in patients, resulting in inconsistent results in previous studies on light therapy in insomnia and depression. This causes scholars and the medical world to still have doubts regarding light therapy and is a reason why light therapy is not popular.

Professor Yiing Mei Liou's team from the National Yang Ming Chiao Tung University developed an ergonomic intelligent lighting system owing to the aforementioned shortcomings. Considering ergonomic factors, the system relies on ambient light to increase distance and decrease avoidance. After understanding the lifestyle of a patient, the system can be installed at a suitable site. The system turns on automatically after installation. Therefore, it decreases manpower and prevents the problem of forgetting to turn on the light. Novel advanced optical technologies were used by Liou's team, including pseudo-sunlight, special emission angles, special spectral adjustment, and diffuse reflection. After stringent human trials, their results proved that 20 treatment courses greatly improved neuropsychiatric symptoms, decreased depression in 70% of patients, and had optimal results. Patients who were irradiated for one hour could sleep for two hours more on average. Parasympathetic nervous activity was increased and brought forward by 2 hours. There was not much difference compared with 40 treatment courses, showing that 20 treatment courses are sufficient. Surprisingly, depression decreased in 50–60% of subjects four weeks after discontinuation, showing extended effects. These findings not only provide hope for depression and insomnia patients but also establishes a standard for treatment courses [17].

New applications and progress of light therapy

Therefore, we require three types of healthy lighting:

1: Dynamic LED lighting conforming to the circadian rhythm: Normal indoor lighting follows the normal work and rest cycle. Light intensity, color temperature, and spectrum that are adjusted at specific times and levels can decrease artificial light pollution and is required in this era. In the morning, white light LED with a color temperature of 6,000 K is used to rouse subjects. The light intensity is gradually increased. At this moment, the subject's vision, mental state, and subjective feelings are at their peak, and work efficiency is at its highest. A high color temperature will inhibit melatonin secretion, causing people to feel excited and nervous, but attention should be paid to exhaustion and fatigue. After noon, white light LED (500 lux) with moderate to high color temperature is used, and the color temperature is gradually deceased; the subject's physical and visual experience satisfaction is at its highest, and physiological and psychological relaxation is gradually achieved. During rest, low color temperature (2,700 K) and low light intensity (300 lux) warm white light LED is used. The low color temperature causes

people to feel comfortable, relaxed, and sleepy, and achieves physiological and psychological relaxation [53]. The various LED parameters can vary with time and scenarios to change subjective feelings and physiological effects and decrease artificial light pollution. With regard to commercial usage, the United Nations currently advocates ESG, which represents an environmental (E), social responsibility (S), and governance (G) approach. It is an indicator for evaluating good companies and represents corporate social responsibility. Dynamic LED lighting for circadian rhythm is a healthy and energy-saving lighting system with good illumination and energy-saving efficiency that can decrease 50% of energy while conforming to green energy and healthy construction. WELL Light concept indicators can help decrease energy consumption and costs, and increase company and building value.More importantly, it has a significant impact on health and safety: when adjusting the circadian rhythm to enhance work/study focus, improve sleep quality, emotional stability, motivation, and reduce fatigue, error rates, and the risk of chronic diseases, it not only represents a contemporary trend but also a crucial consideration for businesses.Healthy lighting will be a future trend owing to the promotion of the European Union's regulations for 2050, such as healthy lighting standards, and IWBI's WELL standards.

2:Good sleep lamp and joy lamp: Lamps with therapeutic effects, specific wavelengths, color temperature, and light intensity. Healthy lighting products must provide a stable wavelength, color temperature, and light intensity to produce different physiological stimuli, which makes them expensive. Meeting the requirements for health and efficacy demands rigorous human studies, peer-reviewed journal publications, obtaining patents, and FDA certification, all of which require investments of both funds and time.

3:Comfortable sleep lamps: Lamps are essential modern nighttime illumination products. With the disappearance of natural light at night, artificial lighting will provide nighttime illumination and provide safety and comfort. However, 10 lux will inhibit nocturnal melatonin secretion. The development of lamps that are brighter but do not inhibit melatonin secretion or do not affect melatonin secretion during nocturnal observation in a healthcare setting are pressing issues. Organic light-emitting diodes (OLEDs) can remove blue light present in original LEDs and decreases the effects of artificial lighting on melatonin secretion, thereby promoting human health [4]. OLEDs have the following three characteristics:1.) They use no blue light illumination to achieve illumination without disrupting human physiological functions; 2.) OLEDs have broad spectral wavebands that are 63% similar to sunlight and are an ideal high-quality product; and 3.) Compared to LEDs and fluorescent lights, OLEDs are less harmful to human health and have also become the mainstream for nighttime illumination[54]. However, durability and commercial viability still pose challenges.

Challenges and problems of light therapy

The pathogenesis of depression is extremely complex. It is clear that depression has been proven to be intimately associated with melatonin. The light intensity, color temperature, spectrum, angle, and human factor considerations of irradiance can affect serotonin and melatonin concentrations, thereby regulating the biological clock. Artificial lighting is a new treatment method for depression. LEDs can not only allow light and color adjustment but can also allow for customized smart functions that can be used to adjust the most suitable lighting environment based on the different needs of patients. This provides a comfortable experience, thereby becoming a new trend for treating depression and insomnia.

Overall, light therapy has huge application prospects as a non-invasive and simple treatment without side effects. In the future, further examination of its mechanism of action, clinical applications, and development directions can be carried out to increase its therapeutic effects and application value.

Conflicts of interest

The authors declared no conflict of interest.

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Introduction and Implementation of Taiwan Suicide Prevention Act

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Abstract: Suicide is a global health and social issue. In Taiwan, suicide prevention has become a national health priority of the government for nearly two decades. The central government established the national Taiwan Suicide Prevention Center (TSPC) and implemented the national prevention strategies in 2005. However, there are still challenges in suicide prevention. Many people at suicide risk still lack access to mental health and social services. In addition, the inappropriate reporting of suicide incidents by the news media and the rapid dissemination of wrong information by social media led to imitation behaviors (copycat) of some high-risk suicide people. Thus, the Taiwanese Society of Suicidology (TSOS) initiated a task force in 2013, involving multi-interdisciplinary experts from mental health care and justice, and held three times of public hearings to prepare the Suicide Prevention Act (SPA). The final draft of the SPA was sent to the Ministry of Health and Welfare for approval in 2018. Through continued promotion by TSOS, the draft of SPA was submitted to the Social Welfare and Health Environment Committee of the Legislative Yuan for review on May 10, 2019, and was finally promulgated by the President on June 19. This article presented the contents and implementation of SPA as well as its short-term outcome in three years.

Keywords: suicide prevention, law, suicide prevention reporting and aftercare system, Taiwan.

Introduction

Suicide is caused by a series of interactions involving multiple factors in terms of physical disease, mental disorders, interpersonal conflicts, psychological distress, and psychosocial stress. Both suicide attempts and suicidal mortality could have a great negative impact on the whole society. In Taiwan, the issue of suicide has received attention from the government for years; the national Taiwan Suicide Prevention Center (TSPC) and the Community Mental Health Center were established as early as 2005. However, there are still challenges in suicide prevention. Many people at suicide risk still lack access to mental health and social services, which makes these individuals unable to receive adequate support and assistance when they are in need, leading to more complex situations. In particular, only when individuals in a severe psychotic condition or at risk of harming themselves, mandatory emergency treatment can be provided according to the "Taiwan's Mental Health Act", but in other mental conditions, there is no related regulation applicable for the compulsory treatment.

Besides, community follow-up care visits for suicide attempters also faced difficulties in practice. For example, due to the provisions of the "Computer-Processed Personal Data Protection Act, it is difficult to provide personal data to the required units through the Internet. Then it will be difficult to provide timely and appropriate assistance or there may be doubts in individual cases. In recent years, the inappropriate reporting of suicide incidents by the news media and the rise of internet use and social media disseminate rapidly various kinds of wrong information that instigates and encourages suicide, which has widely affected social cognition and led to imitation behaviors (copycat) of some high-risk suicide people. The above difficulties indicated that the connection, support, and integration of suicide prevention networks need to be strengthened, so that the importance of the legislation becomes an urgent issue.

In recent years, the East-Asia countries began actively to formulate laws for suicide prevention. For example, Japan enacted the "counter-suicide white paper" in 2006; South Korea announced the "Act on Prevention of Suicide and the Establishment of a Society and Culture Respecting Life" in 2011, including integrating central and local government resources, compiling relevant legal guarantees such as budget and intervention in the autonomous field of others, improving the suicide prevention, and provide the country a clear legal basis for promoting suicide prevention policies. Based on the faith that "life is priceless", Taiwan referred to the legislative experience of Japan, South Korea, and other countries to formulate a "Suicide Prevention Act" (SPA) to save those who are in danger of suicide, at risk of suicide, and those who are affected by suicide.

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Legislative History

In order to formulate and promote the SPA, the Taiwanese Society of Suicidology (TSOS) under the leadership of Ming-Been Lee (corresponding author) initiated a task force in 2013. A systematic review was conducted first on domestic and foreign documents and regulations related to the suicide prevention law; compiling and analyzing the information, the TSOS held seven expert meetings involving multi-interdisciplinary experts from various fields of mental health care and justice, and three public hearings to finalize the draft of SPA and send it to the Ministry of Health and Welfare for approval. However, it was postponed until 2018 when the TSOS promoted the legislation again. Expert meetings were held again and a number of legislators were visited to consolidate and strengthen the explanations of the indications for the draft laws and regulations. Through several revisions to the structure of the regulations, the draft of SPA was submitted on May 10, 2019, to the Social Welfare and Health Environment Committee of the Legislative Yuan for review. After the first reading, the Legislative Yuan convened the 16th session of the 9th seventh session to pass the second reading and third reading of 19 articles on May 31. Finally, on June 19, the SPA was promulgated by the President. So far, Taiwan has become one of the few Asian countries that enacted a special suicide prevention law after Japan and South Korea.

Specification Focus

The purpose of the legislation of the SPA is to take care of the safety of people's lives and to cultivate society's respect for the value of life. Article 1 states: "This law is specially enacted to strengthen the suicide prevention (SP), care for the safety of people's lives, and cultivate society's respect for the value of life"; and Article 3 states that since SP is based on individual, family, and social determinants, it shall be implemented with the strategy of inputting whole society resources into aspects of biology, psychology, society, economics, culture, education, and labor.

The four key aspects of legislation and regulation are:

(1) The central competent authority should formulate a national suicide prevention program, and stipulate in Article 4 the establishment of an inter-ministerial suicide prevention and prevention advisory committee to promote, support, coordinate, and integrate SP tasks among various departments Prevention work.

(2) Article 6 of this act states that all agencies, schools, legal persons, institutions, and groups should cooperate with the central government, municipalities, and county or city competent authorities to carry out SP tasks, conduct SP education, and provide psychological counseling channels. If necessary, ask the agency to assist in providing relevant information.

(3) In addition, Article 7 also stipulates that governments at all levels should allocate budgets for SP every year to implement SP tasks and allocate sufficient financial resources in order to break through the turnover rate of manpower related to front-line SP and excessive bottlenecks, and improve their professional quality.

(4) Articles 16 and 17 regulate media (including promotional materials, publications, radio, television, Internet, etc.), or inciting others to commit suicide and other related wrong information will be punished with administrative penalties.

Responsibilities of the National Suicide Prevention Center

According to Article 9, Item 2, the central competent authority may entrust juridical persons and groups to set up the National Suicide Prevention Center (i.e., current Taiwan Suicide Prevention Center, TSPC) to conduct surveys on the current status of suicide prevention practice, analyze the suicide data characteristics and propose suicide prevention recommendations, prepare annual reports on suicide prevention results, and provide recommendations. Special Municipality and County /City competent authority shall promote suicide prevention according to local conditions to promote and conduct education and training SP gatekeepers, establish and improve the suicide prevention reporting and aftercare system, promote suicide prevention in medical institutions, and conduct supervision, communication, and counseling, assist the media and Internet platforms to abide by the principles of suicide news reporting and establish a self-regulatory mechanism and other suicide prevention related matters.

In fact, before the promulgation of the SPA, the Ministry of Health and Welfare had successively entrusted the Taiwanese Society of Suicidology to handle the above-mentioned businesses, including "counseling Special Municipality and County / City competent authority to promote SP according to local conditions". What currently stands is the monthly and quarterly SP reporting data analysis and rolling SP strategy recommendations, as well as the annual suicide death and suicide attempt analysis and recommendations. Six counties and cities are selected for on-site counseling visits every year; in-depth analysis is conducted and refinement of strategic recommendations is tailored to local conditions. In addition, there is also the "establishment and improvement of the suicide

prevention reporting and aftercare system": the original case visit procedures and case closing standards, etc., need to be reviewed and revised to improve the quality and efficiency of visits.

Implementation of Suicide Prevention Strategy

Article 10 of the SPA stipulates that the central competent authority shall set up or entrust a 24-hour toll-free emergency hotline for suicide prevention without payment. The Ministry of Health and Welfare established the "1925' counseling hotline" before the passage of the bill to provide 24-hour telephone counseling services to all people, in order to timely rescue those who want to commit suicide due to stress or depression.

Article 12 stipulates that competent authorities at all levels shall establish mechanisms to reduce the public's chances of obtaining highly lethal suicide tools or implementing highly lethal suicide methods. In recent years, the central government has launched some mechanisms to reduce highly lethal suicide tools or techniques, including strategies to ban paraquat and prevent falling from height. Among them, the processing

and import of paraquat have been banned since 2018 and its use has been officially banned since 2020. The number of suicide deaths due to paraquat has dropped significantly from 227 in 2017 to 67 in 2020, showing the positive effect of the ban on SP (Figure 1).

National Suicide Surveillance System

In accordance with Article 11 of the SPA and Article 13 of the Implementing Rules, the central competent authority shall establish a suicide reporting system to provide the notification of suicidal attempts, and all relevant personnel shall carry out notification within 24 hours after learning of suicide behavior to facilitate after-care visits. A total of 40,432 suicide notifications were reported in 2020, with an increase of 7.5% than 2019; 14,812 were men and 28,672 were women (Figure 2). Combined with suicide deaths and other data, the increase in the notification number represents that suicide notification has been promoted continuously. This is consistent with the policy of encouraging notification to be as widespread as possible. In particular, the proportion of reporting from education units increased from 2.8% in 2019 to 6.6% in 2020, an increase of 1,698 cases (Table1).
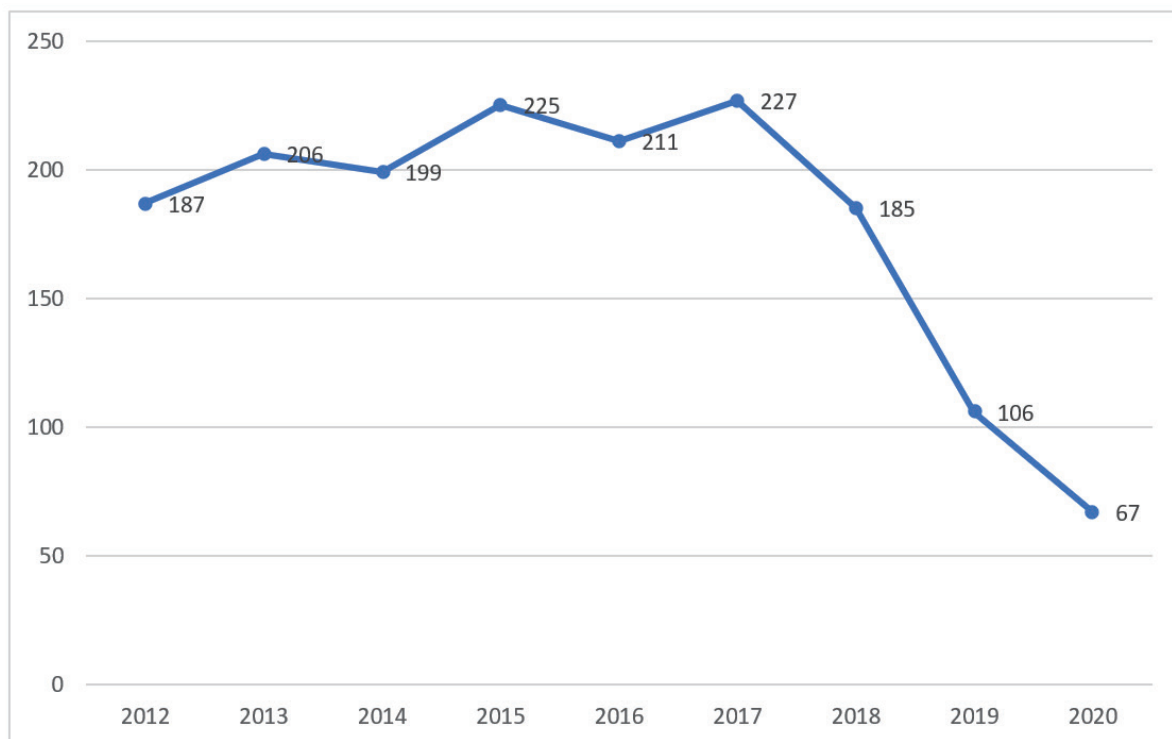
Figure 1. The number of suicide deaths in paraquat from 2012 to 2020.
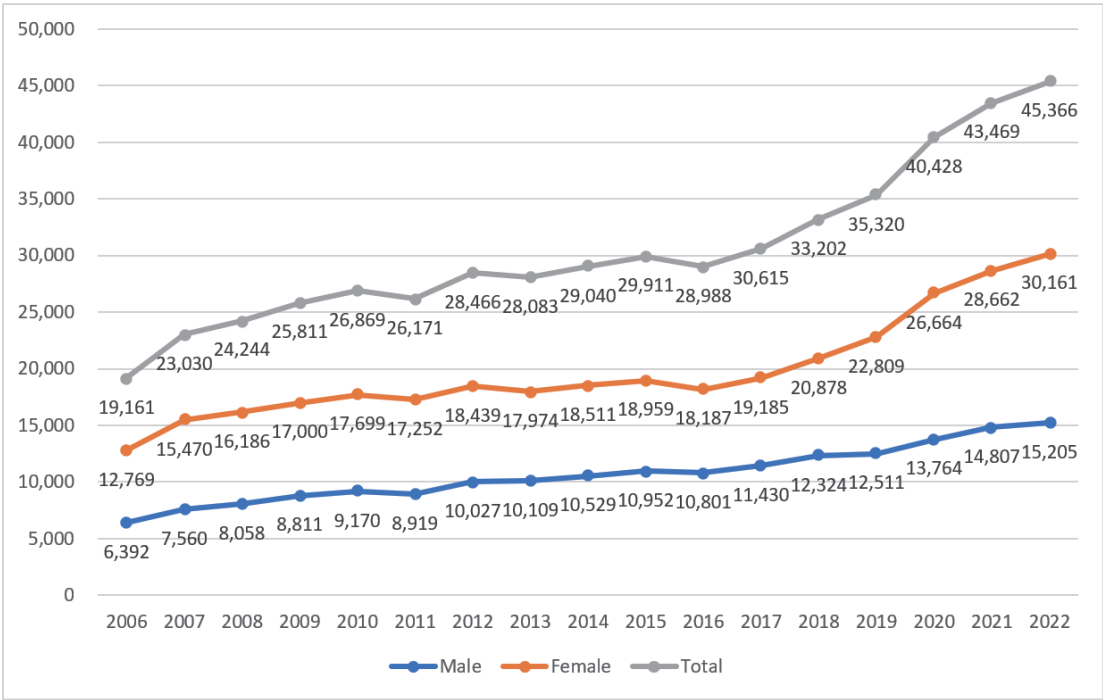
Figure 2. Number of suicide attempt reports from 2006 to 2022.

Table 1. The distribution of suicide attempter reporting units in 2019 and 2020.

	2019		2020	
Units	Number of reports (N)	(%)	Number of reports (N)	(%)
Medical institutions	28,397	80.4	29,811	73.7
Police/Fire Units	3,780	10.7	4,942	12.2
Health Bureau	1,462	4.1	1,566	3.9
Social Affairs	390	1.1	790	2
Judiciary	51	0.1	95	0.2
Labor	1	0	1	0
Education	982	2.8	2,680	6.6
Civil Affairs	19	0.1	12	0
Unknown	0	0	0	0
Others	242	0.7	535	1.3

Suicide News Norms for Media Coverage

Another focus of the SPA is the regulation regarding suicide news or information on the Internet and media reports. The media has always played an important role in suicide prevention. It is not only the main channel for the public to acquire suicide-related information, but also an important carrier for national policy advocacy. According to past research, media reports may lead to a copycat effect when inappropriate suicide news is transmitted. On the contrary, appropriate media reports can help promote SP and enhance help-seeking willingness. When the media emphasizes SP knowledge through education in their reports, it is conducive to the implementation of the overall prevention work.

Therefore, in Articles 16 and 17 of the SPA, it is stipulated that publicity materials, publications, radio, television, Internet, or other public media shall not report suicide news. The prohibited report contents include the following: (1) detailed descriptions of suicide methods and the causes; (2) information about fear of suicide instigation; (3) presentation of the text, sound, picture or video materials that induce suicide intention. Moreover, Act 17 writes the penalty for the media that violates Act 16 to reduce inappropriate suicide news. After the SPA was passed, there was an effect of reduction in the number of media reporting on suicide and an enhancement of more responsible reporting within two years. According to the daily suicide news monitoring analysis performed by the Taiwan Suicide Prevention Center, four major online media's adherence rate to the WHO Six 'Donts" and Six "Dos" Suicide News Reporting Guideline has increased significantly (Table 2).

Conclusion

Suicide prevention takes the initiative and efforts of every citizen. It also needs close collaboration between the general public and the government to develop a compassionate culture and create a care environment for people in different aspects. The SPA ensures a comprehensive and transparent delivery plan for suicide prevention across national and local governments and their associated agencies. After the legislation in 2019, the number of suicidal events reported by the media has decreased significantly. While the national suicide rate reached 11.8 per 1,000,000 in 2020 (Figure 3), more efforts need to be made based on the SPA to provide more protection and resources for people at risk. The Ministry of Health and Welfare has issued a regulation and invited professionals and scholars to participate in meetings, making suicide prevention networks more comprehensive and adaptive to local needs including the public media. Our future task is to strengthen connection, support, and integration of various suicide prevention systems at the local and central levels, and to make the entire SP networks linked with each other.

It is possible to save more precious lives if more SP gatekeepers in the networks carry out their roles and functions, and the whole society respects the value of human lives more. Although the private NGOs in Taiwan have already demonstrated their power in suicide prevention for a long time, with the enactment of SPA the public and private sectors can be more closely integrated to contribute to suicide prevention and treatment. In addition, after the implementation of SPA, suicide is no longer a personal matter. The network system has also changed from "responsibility notification" to "statutory notification". In this way, the content and level of detail of the notification can be used as an effective system

Table 2. The rates of adherence to WHO guidelines of six "Dos" and six "Don'ts" for four major online newspapers before and after the passage of the Suicide Prevention Act.

| WHO guidelines of don'ts	Before (%)	After (%)	P-value	WHO guidelines of dos	Before (%)	After (%)	P-value
No specific details	86.8	90.6	0.000	Present relevant data only on inside pages	96.0	99.4	0.000
No simplistic reasons	38.7	58.3	0.000	Discus with experts	1.4	1.4	0.967
Do not glorify or sensationalize	97.2	97.7	0.140	Refer to completed not successful suicides	98.9	99.9	0.000
No religious or cultural stereotypes	98.9	99.4	0.024	Highlight alternatives	22.4	25.9	0.000
Do not apportion blame	99.1	99.7	0.001	Provide helplines information	91.3	92.7	0.018
No photos	19.2	10.0	0.000	Publicize risk indicators	8.7	5.4	0.000
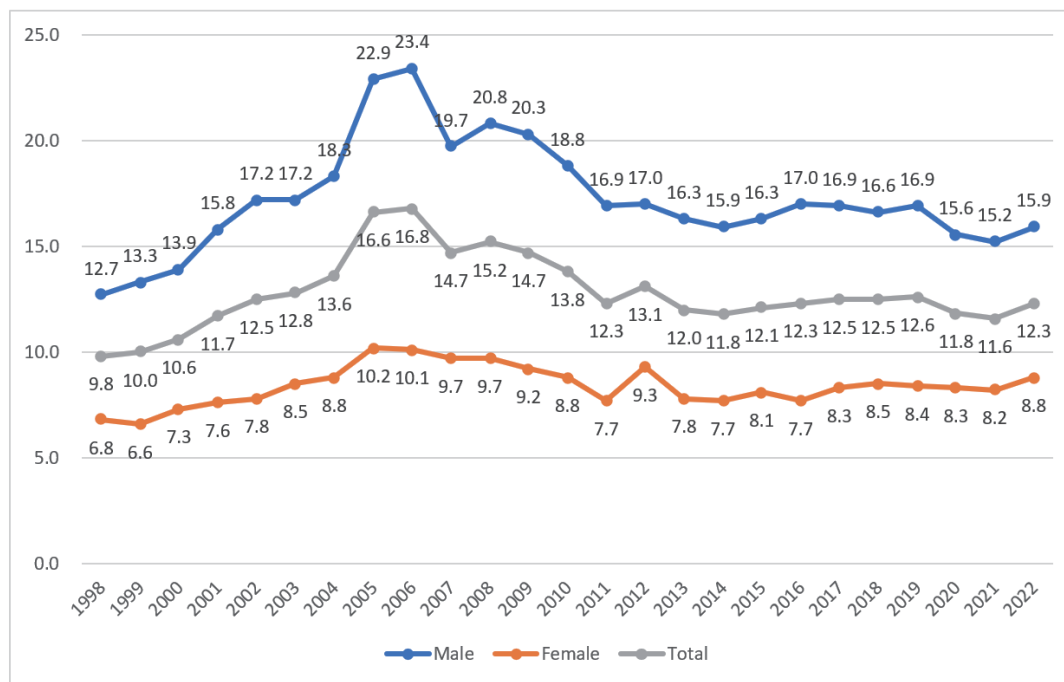
Figure 3. Standardized suicide mortality rates from 1998 to 2022.

analysis in national policies and resource management. In the near future, with complete reporting information, more in-depth care can be provided and predictive and preventive models can be implemented as early as possible.

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Appendix : Suicide Prevention Act

Article 1

The Act is enacted in order to strengthen suicide prevention efforts while caring for the people's lives and safety, and cultivating respect for life value in society.

Article 2

The term "competent authority/authorities," as used herein, shall refer to the Ministry of Health and Welfare at central government level, the municipal governments at municipality level, and the county/city governments at county level.

Article 3

Taking into considerations of individual, family and social determinants, suicide prevention shall be implemented with the strategy of inputting whole society resources into aspects including biology, psychology, society, economics, culture, education, labor, among others.

Article 4

The central competent authority shall establish a suicide prevention advisory committee cross ministries and councils in order to facilitate the implementation, support, coordination, and integrations of suicide prevention tasks across governmental departments.

Article 5

- Each municipal or county/city competent authority shall establish an inter-departmental suicide prevention committee for the purpose of coordination, counseling, supervision, assessment, and implementation regarding suicide prevention practices.
- The composition, missions, meeting procedures and other matters to follow of the aforementioned suicide prevention committee shall be determined by the municipal or county/city competent authorities.

Article 6

- All government agencies, schools, legal persons, institutions, and organizations shall cooperate with the central, municipal, or county/city competent authorities in implementing suicide prevention practices, delivering suicide prevention educational programs, and providing channels for accessing psychological counseling.
- Under the necessity of implementing suicide prevention practices, the central competent authority may request related government agencies to provide assistance or relevant data.
- The central, municipal, or county/city competent authorities may, when necessary, subsidize the fees for suicide prevention educational programs and channels for accessing psychological counseling under paragraph one.

Article 7

- The governments at all levels shall allocate budgets annually to fund suicide prevention for executing relevant matters stipulated in this Act.
- The central competent authority shall reward the municipal or county/city competent authorities that achieve outstanding performance in implementing suicide prevention programs.

Article 8

- The municipal or county/city competent authorities shall appoint personnel related to suicide prevention implementation and improve their professional skills.
- Regulations governing the qualifications, training, education programs and other relevant matters of the personnel related to suicide prevention implementation under paragraph one shall be formulated by the central competent authority.
- When necessary, the central competent authority shall subsidize the municipal or county/city competent authorities in regard to the matters set forth in the preceding two paragraphs.

Appendix (Cond't) : Suicide Prevention Act

Article 9

- The central competent authority shall formulate national suicide prevention guidelines which shall be enforced after submission to and ratification by the Executive Yuan.
- The central competent authority may commission a legal person or organization to set up a national suicide prevention center to handle the following matters:

    1. Surveying the current status of suicide prevention practices.
    2. Conducting analysis of suicide data characteristics and preparing suicide prevention recommendations.
    3. Preparing reports on suicide prevention results every year.
    4. Advising the municipal or county/city competent authorities in implementing suicide prevention measures that suit local conditions.
    5. Promoting and organizing the education and training of suicide prevention gatekeepers.
    6. Establishing and improving the system of suicide prevention reporting, aftercare and visit.
    7. Promoting matters of suicide prevention at medical facilities and engaging in supervision, communication and guidance.
    8. Assisting the mass media and Internet platforms in following the principles for suicide news reporting and establish a self-regulatory mechanism.
    9. Other matters related to suicide prevention.

- The suicide prevention gatekeepers mentioned in the fifth subparagraph of the preceding paragraph refer to persons who are aware of suicide prevention concepts and capable of identifying suicide risk and taking actions such as assistance and referrals in order to prevent others from engaging in suicidal behavior.
- In the course of performing commissioned duties the legal person or organization mentioned in the second paragraph may collect, process, or use the necessary personal data.

Article 10

The central competent authority shall set up or entrust an entity to run a 24-hour toll-free suicide prevention emergency counseling hotline.

Article 11

- The central competent authority shall establish a national suicide prevention report system through which the medical personnel, social workers, long-term care providers, school faculty and staff, police officers, firemen, correctional facility staffs, village chiefs, village officers, and other related practitioners may engage in suicide prevention reporting upon becoming aware of events of suicidal behaviors.
- The methods and contents of the aforementioned reporting shall be determined by the central competent authority. The identity of the reporting persons shall be kept confidential.
- Upon receiving the reports, the municipal or county/city competent authorities shall take action immediately. When necessary, competent authorities may engage in or commission other agencies, institutions or organizations to provide aftercare and visit.

Article 12

The competent authorities at all levels shall establish mechanisms to reduce opportunities for people to access to highly lethal suicide tools or to utilize highly lethal suicide methods.

Article 13

In order to prevent suicide reattempts, the municipal or county/city competent authorities shall provide suicide attempters and their family or friends with referrals to resources of psychological counselling, medical treatment, social welfare, education, employment and others.

Article 14

The municipal or county/city competent authorities or the agencies, institutions, organizations commissioned by such authorities may request assistance from the police agencies, medical institutions, schools, or other related agencies or institutions in regard to aftercare and visit services. Recipients of such a request shall cooperate.

Appendix(Cond't) : Suicide Prevention Act

Article 15

- All agencies, schools, legal persons, institutions, organizations, and related practitioners shall, in the course of engaging in practices related to this Act, keep confidential the personal data of persons with suicidal behavior and their family or friends; they shall not disclose such information without justification.
- The municipal or county/city competent authorities shall impose a fine of not less than NT$6,000 and not more than NT$60,000 on any entity that discloses without justification the abovementioned personal information.

Article 16

Promotional materials, publications, radio, television, the Internet, or other media may not report or contain the following matters:

1. Messages that tutor suicide methods or instigate, lure, or provoke people to engage in suicidal behavior.
2. Detailed descriptions of the suicide method and cause of a suicidal person.
3. Texts, audios, images, or videos that may induce people to engage in suicidal behavior.
4. Information about the sales of toxic substances or other lethal suicide tools.
5. Other circumstances, as deemed by the central competent authority, sufficient to encourage suicidal behaviors.

Article 17

- In the event that a radio or television station violates the provisions of the preceding article, the authority in charge of the industry shall impose a fine on the violating station not less than NT$100,000 and not more than NT$1,000,000 and order it to make corrections within a specified period of time. Fines may be imposed consecutively in case the violating station fails to make corrections when the specified period expires.
- Except for those specified in the preceding paragraph, in the event of violation of the preceding article by promotional materials, publications, the Internet, or other media, the municipal or county/city competent authorities shall impose a fine on the person in charge and related offenders not less than NT$100,000 and not more than NT$1,000,000, and may confiscate the items specified in the preceding article or order them to remove the offending content, withdraw the items, or undertake other necessary measures within a specified period of time. Fines may be imposed consecutively in case of failure to comply with the orders when the specified period expires.

Article 18

The enforcement rules of the Act shall be enacted by the central competent authority.

Article 19

The Act shall become effective on the date of promulgation.

A Validity Study of Five-Item Suicide Narrative Inventory (SNI-5) to Identify the Suicidality in General Population: An Online Survey in Taiwan

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Abstract: *Background:* Suicide crisis syndrome (SCS) was proposed as a suicidal mental state. The suicide narrative was reported to closely associate with SCS. The 38-item Suicide Narrative Inventory (SNI) has been validated to identify the SCS and suicidality among community residents in Taiwan. The study aimed to develop a shorter form of SNI named the five-item Suicide Narrative Inventory (SNI-5) for use to screen the potential SCS and related suicidality. *Methods:* An anonymous online questionnaire survey with structured questions on suicide risks was conducted in 2021. All the participants were aged over 20 and completed the surveyed questions including demographics, 38-item Suicide Narrative Inventory (SNI), 5-item Suicide Crisis Scale (SCS-5), 5-item Brief Symptom Rating Scale (BSRS-5) and, suicidality assessment (i.e., suicidal ideations and attempts). The SNI-5 contained five items (i.e., perceived burdensomeness, social defeat, entrapment, fear of humiliation, and perfectionism); each item was selected from those with the highest correlation with the original corresponding subscale of SNI. Confirmatory factor analyses (CFA) and internal consistency of the SNI-5 were performed. The convergent validity of the SNI-5 was examined with the SCS-5, BSRS-5, and suicidality. Stepwise multiple regression and receiver operating characteristic (ROC) curve were used to evaluate the predictive validity of the SNI-5 on one-week suicidal ideation (SI). *Results:* A total of 4,846 participants were enrolled with female predominance (82.6%). Results of the one-factor CFA for SNI-5 indicated a good model fit. The SNI-5 demonstrated adequate internal consistency (Cronbach alpha: .78) and significant correlations with BSRS-5, SCS-5, and suicidality. Stepwise multiple regression revealed that items of perceived burdensomeness, social defeat, and entrapment significantly explained 20.0% of the variance of one-week SI. ROC curve indicated that the optimal cut-off 14 of the SNI-5 could significantly differentiate the one-week SI. *Conclusions:* The study revealed that the SNI-5 had satisfactory psychometric properties in terms of reliability and validity among the general adult population in Taiwan. However, if the SNI-5 significantly represents the original SNI construct and its predictive validity for future suicide behaviors needs further investigation in the vulnerable population.

Keywords: suicide crisis syndrome, Five-item Suicide Crisis Scale (SCS-5), Five-item Suicide Narrative Inventory (SNI-5), near-term suicide risk, psychological distress, BSRS-5.

Introduction

Development of suicidality is a long-term process from suicide risks and suicidal ideation (SI) to completed suicide [1-4]. It is critical to early identify SI and its associated imminent risk factors to prevent suicide behavior (SB). Mental distress associated with psychiatric disorders and psychosocial stress are the major proximal risks [5-8]. Other than traditional suicide assessment on long-term factors, early identification of psychological distress [9-12] and suicidal mental conditions (e.g., suicidal crisis syndrome, SCS) has increasingly attracted the health professionals [13-16]. The SCS comprises five dimensions: entrapment, affective disturbance, loss of cognitive control, hyper-arousal, and social withdrawal [17-19]. Its construct has demonstrated predictive validity in predicting short

term SB among high-risk sub-groups [20,21]. The revised Suicide Crisis Inventory (SCI-2) was created and validated to fulfil the revised SCS formulation [15, 22, 23].

Most of traditional suicide risk assessment tools largely overlooked the interactive and time-sensitive components resulting from a complexly intertwined factors from individual characteristics, mental disorders, interpersonal networks, and cultural factors, to stressful life events. Thus, a Narrative-Crisis Model (NCM) was proposed to formulate that the suicidal crisis emerges from the dynamic interactions of three components: trait vulnerability, the suicidal narrative, and the negative mental state of SCS [24-27]. The trait vulnerability component of NCM consists of static risk factors that are distal to the acute appearances of suicidal behaviors, including past history of trauma and personality traits

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such as hopelessness, fearlessness, perfectionism, and insecure attachment [28-30]. The suicidal narrative, on the other hand, focuses on the psychological distress associated with the characteristic life narrative of a suicidal individual (i.e., a sense of worthlessness emerging from narratives of past life events, as well as hopelessness with the future). Suicidal narratives have indicated significant associations between acute cognitive and emotional responses and imminent suicidal risk [24,31,32].

The suicidal narrative construct comprises six factors: thwarted belongingness, perceived burdensomeness, humiliation, social defeat, goal disengagement, and goal re-engagement; the first four are grouped into "interpersonal factors" deriving from the interpersonal theory and integrated motivation-volitional model of suicidal behavior, and the latter two are classified as "goal orientation factors", deriving from the goal disengagement theory. The Suicide Narrative Inventory (SNI) [23] was thus developed and comprised 102 questions on a 5-point Likert scale. It includes the above-mentioned six subscales. Same as previous reports [23,24,33], interpersonal but not goal orientation was associated with a combined variable assessing suicidal thoughts and behaviors. In our previous report, the Taiwan version of SNI performed good psychometric properties with a seven-factor solution and could significantly determine the past-week SI and SCS measured by SCI-2 [33]. The present study aimed to 1) develop a shorter form of the SNI named five-item Suicide Narrative Inventory (SNI-5) as a screening tool for use in clinical or community settings; and 2) examine its validity in terms of factor structure, internal consistency, and convergent validity in a general population survey in Taiwan.

Methods

Participants and procedures

The study was part of the International Suicide Prevention Assessment Research for COVID-19 (I-SPARC) led by Professor Galynker, investigating pre-suicide near-term mental states and associated risks under COVID-19 across 14 countries. The cross-sectional online survey with a convenience sample was conducted in Taiwan between 7th April and 4th May 2021.

Social media users who identified the study information and were aged over 20 were invited to take part in this project. The inclusion criteria included Mandarin-speaking and cognitively intact to consent and complete the questionnaire. In total, 4846 participants who completed all the surveyed questions were recruited for analysis.

Ethical approval

The ethical approval was acquired by the Institutional Review Board at the corresponding author's affiliated university hospital (202101118W). All the participants were informed on the first webpage and agreed to participate.

Measures

All the questionnaire items of the I-SPARC were translated into Chinese and established on in Qualtrics website. The Taiwan research team further finalized the Taiwanese version of the questionnaire including an additional scale of BSRS-5. The measures used in the present study were described as follows:

Five-Item Suicide Crisis Scale (SCS-5)

A self-rating scale SCS-5 was used to measure the near-term suicide risk. It contains five-dimensional items derived from the Suicide Crisis Inventory version 2 (SCI-2) [15,18,20-22]: hyper-arousal, affective disturbance, loss of cognitive control, entrapment, and social withdrawal. Each item was rated by respondents on a five-point Likert scale based on how they felt when they felt the worst over the last several days: 0, not at all; 1, a little; 2, somewhat; 3, quite a bit; 4, extremely. The total and dimensional scores were used to judge the global severity and dimensional symptom profile of the SCS. The SCS-5 performed good reliability and validity to detect suicidality in the previous report [15,16].

Five-Item Brief Symptom Rating Scale (BSRS-5)

The BSRS-5 is a self-report scale with satisfactory validity for the identification of psychiatric morbidity and suicidal ideation in both clinical and community populations [34-37]. The BSRS-5 contains the following five items: (1) insomnia; (2) anxiety; (3) hostility; (4) depression; (5) inferiority. Participants were asked to rate the degree of distress from each item of BSRS-5 during the week preceding the assessment: 0, not at all; 1, a little bit; 2, moderately; 3, quite a bit; 4, extremely, with a total score ranging from 0-20. An additional item with the same rating method was used to assess the degree of perceived suicide ideation in the recent week.

5-Item Suicide Narrative Inventory (SNI-5)

The Abbreviated Suicide Narrative Inventory (SNI) is a self-rating scale, comprising 38 items including the following eight subscales: 1) thwarted belongingness, 2) perceived burdensomeness, 3) fear of humiliation, 4) defeat, 5) goal reengagement, 6) goal disengagement, 7) entrapment, and 8) perfectionism [24, 33]. Each item was rated on a five-point Likert scale, based on how the respondents viewed themselves over the last month, ranging from 1 to 5, with 1 being not true at all, and 5 being extremely true. In our previous report, modification indices for the Taiwan version of SNI indicated that the goal disengagement factor was problematic; in conjunction with the poor internal consistency of the items, the items of three-goal disengagement were thus removed. The Taiwan version of SNI performed good psychometric properties with a seven-factor solution [33]. The validity of SNI excluding the subscale of goal disengagement had a satisfactory psychometric property in terms of factor structure, internal consistency, and convergent validity with SCI-2, BSRS-5, and suicide assessment [33]. In the study, seven items were selected to form a new scale based on the highest correlation with the corresponding subscale of the Taiwan version

of SNI. After examination, two of the seven items SNI performed unsatisfactory psychometrics in terms of the reliability and factor structure: goal reengagement and thwarted belongings. In addition, the statement of these two items were described as positive and protective factors, but reversely recoded to fulfil the negative nature of the suicide narratives. Thus, a newly developed SNI-5 contained the other five items (i.e., perceived burdensomeness, defeat, entrapment, fear of humiliation, and perfectionism).

Suicide-Related variables

Apart from past-week suicidal ideation, four yes/no questions were inquired to assess specific suicide risks in the study: whether the participant had suicide attempts or serious SI respectively in the past month and/or lifetime. These self-reported responses were recorded to indicate the participant's prior experience with SB and reflect different levels of suicide risks.

Statistical analysis

Regarding the validity of the SNI-5, the data were first screened using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy [38] and Bartlett's test of sphericity [39] to determine their suitability for factor analysis. Confirmatory factor analysis (CFAs) was then conducted to test the proposed one-factor structures of the SNI-5. In the one-factor model of the SNI-5, items were set to load onto their respective subscale factors such as perceived burdensomeness, social defeat, entrapment, fear of humiliation, and perfectionism. Because items were ordinal (i.e., rated on a 5-point Likert scale), we utilized diagonally weighted least squares (WLS) estimation. Model fit was evaluated using recommended guidelines (Hu & Bentler, 1999) [40], including the chi-square statistic ($\chi 2$), comparative fit index (CFI), Tucker-Lewis index (TLI), root mean squared error of approximation (RMSEA), and standardized root mean residual (SRMR). Specifically, good model fit was indicated by a non-significant $\chi 2$ statistic, CFI $\geq$ .95, TLI $\geq$ .95, RMSEA $\leq$ .08, and SRMR $\leq$ .08.

Internal consistency of the SNI-5 was assessed using Cronbach's alpha. Convergent validity was examined by conducting Pearson's correlations between the SNI-5 and other validated measures such as SCS-5, BSRS-5, and suicidality variables. Missing data were handled using listwise deletion; all analyses were conducted in R using the lavaan [41], semTools [42], and psych packages [43]. Further, the ROC curve analysis was performed to determine the optimal cut-off point of the SNI-5 to identify the recent one-week SI. Moreover, stepwise multiple regression was used to examine the associations between SNI-5 item scores and one-week SI. Statistical significance was set at a level of p < 0.05. The SAS 9.4 software package (SPSS, Chicago, IL) was used for analyses in this study.

Results

Demographics and suicidality information of the participants

Among the 4846 participants, the mean age was 37.5 ± 10.8 (standard deviation), and the females predominated (82.6%). Just over half were married (54.8%), and two-thirds graduated from college. The detailed demographics and characteristics were described in our previous study [15]. Of the participants, the prevalence of psychiatric morbidity (BSRS-5>=6) was 23.7% with 11.9% of SI in the past week. The detailed demographics and basic data were described in our previous paper [33].

Factor structure of the SNI-5

The KMO statistics (.79) and Bartlett's test of sphericity ($\chi 2[1830] = 7295.97$, p < .001) each indicated that there were sufficient significant correlations in the data for its use in factor analysis. Results of the one-factor CFA of SNI-5 resulted in good model fit ($\chi 2[5]=142.279$, p<.001, CFI=.98, TLI=.96, RMSEA=.08, SRMR = .04). The factor loadings of the five variables were displayed in Table 1.

Reliability and convergent validity of the SNI-5

Internal consistency of the SNI-5 was adequate (α=.777). Inter-item correlations were all significant with the highest coefficients of 0.674 between defeat and entrapment; 0.566 between perceived burdensomeness (PB) and defeat, 0.534 between PB and entrapment (Table 2). Correlations between the SNI-5 total and constructs of the SCS-5, BSRS-5, and suicide-related variables (i.e., SI in recent one-week /lifetime/past-month, lifetime SA) were presented in Table 3. All constructs were significantly correlated with each other (Table 3). The correlation was highest for the SCS-5 (.600), followed by BSRS-5 (.545), past-week SI (.385), lifetime SI (.321), past-month SI (.286), and lifetime SA (.239). Most of the associations between SNI-5 subscales and suicide-related outcomes were small to moderate in magnitude (Table 4). With respect to one-week SI, the perceived burdensomeness (.405,), defeat (.372), and entrapment (.346) exhibited larger correlations (Table 4). Regarding the association between SNI-5 and BSRS-5 items (Table 5), both defeat and entrapment presented the highest correlations with the severity of the general psychopathology (BSRS-5 score, .515 and .513, respectively), depression (.489 and .470, respectively) and inferiority (.493 and .465, respectively). In summary, each subscale of the SNI-5 had significant associations with each item of the BSRS-5. Considering the associations between SNI-5 and SCS-5 (Table 6), all inter-item correlations reached statistical significance. In particular, the defeat (.572) and entrapment (.560) had the largest correlations with the SCS-5 total. These two items also showed generally higher correlations with all

subscales of the SCS-5. This fulfilled our hypothesis that SNI-5 scores were contributing to the severity of suicide crisis syndrome (measured by SCS-5).

Stepwise regression was performed to estimate the associations between SNI-5 and one-week SI. Entering all items of SNI-5 for stepwise analysis, the standardized coefficients and R2 were displayed in Table 7; perceived burdensomeness (B=.266), defeat (B=.164), and entrapment (B=.109) together explained 20% of the total variance of past-week SI. As the SCS-5 was assessed according to the worst conditions in the past several days and the SNI-5 was rated in the previous one month, path analysis was conducted with SEM model to examine the relationships between the SNI-5, SCS-5, and one-week SI. As shown in Figure 1, all the SNI-5 items (particularly the defeat and entrapment) interacted to influence the SCS-5 score and past-week SI. The resultant model demonstrated good model fit statistics in most of the indicators (CFI = 0.979> 0.9, AGFI = 0.922, RMSEA =0.099 < 0.05) except for Cmin/ Df (48.93 >5, p <0.001).

Finally, the total score of the SNI-5 was significantly correlated to suicide-related variables (e.g., SI in a week/ 1 month/lifetime). Considering the SNI-5 as a screener for one week SI, a score of 14 was determined as the optimal cut-off point by ROC analysis (Figure 2). Using this cutoff, the SNI-5 performed a satisfactory property to identify past-week SI (sensitivity=.798, specificity=.709; positive predictive value [PPV] = 0.271, negative predictive value [NPV= 0.963]). The area under the curve (AUC) was .820 (95% confidence interval =.802-.839). The NPV of 0.963 implies that when the respondent scored less than 14, there was a 96.3% probability that he or she would not have SI.

Table 1. Factor loadings of the one-factor model of the Five-item Suicide Narrative Inventory (SNI-5).

	Factor
Perceived burdensomeness	0.650
Fear of humiliation	0.570
Defeat	0.824
Entrapment	0.814
Perfectionism	0.399

Notes: Principle axis factoring extraction method was used, The cumulative % of Eigenvalues was 54.50. The cumulative % of extraction sum of squared loadings was 44.969.

Table 2. Standardized covariances of the five-item Suicide Narrative Inventory (SNI-5).

	1	2	3	4	5
1.Perceived burdensomeness	1	.333**	.566**	.534**	.242**
2.Fear of humiliation		1	.467**	.453**	.314**
3.Defeat			1	.674**	.279**
4.Entrapment				1	.328**
5.Perfectionism					1

Notes: * p<.05; ** p <.01.

Table 3. Correlations between five-item Suicide Narrative Inventory (SNI-5) subscale scores and other relevant constructs.

	SNI-5	SCS-5	BSRS-5	Recent week SI	Past-month suicidal ideation	Past-month suicide attempt	Lifetime suicidal ideation	Lifetime suicide attempt
SNI-5	1	.600**	.545**	.385**	.286**	.165**	.321**	.239**
SCS-5	.600**	1	.642**	.513**	.387**	.253**	.307**	.243**
BSRS-5	.545**	.642**	1	.518**	.295**	.189**	.288**	.224**

Notes: 1. SCS-5 = Five-item Suicide Crisis Scale; BSRS-5 = 5-item Brief Symptom Rating Scale.
2. ** p < .01.

Table 4. Correlations between five-item Suicide Narrative Inventory (SNI-5) subscale scores and suicidality.

	Recent week SI	Past-month suicidal ideation	Past-month suicide attempt	Lifetime suicidal ideation	Lifetime suicide attempt
Perceived burdensomeness	.405**	.303**	.212**	.262**	.229**
Fear of humiliation	.181**	.127**	.067**	.226**	.153**
Defeat	.372**	.284**	.161**	.257**	.203**
Entrapment	.346**	.241**	.138**	.289**	.204**
Perfectionism	.143**	.123**	.050**	.146**	.097**

Notes: 1. * p < .05, ** p < .01.
       2. Point biserial correlations were conducted when examining lifetime suicide attempts, given that this variable was dichotomous.

Table 5. The correlations between five-item Suicide Narrative Inventory (SNI-5) subscale scores and 5-item Brief Symptom Rating Scale-7 (BSRS-5) scores.

	Insomnia	Anxiety	Hostility	Depression	Inferior	BSRS-5
Perceived burdensomeness	.255**	.304**	.321**	.397**	.384**	.413**
Fear of humiliation	.187**	.266**	.275**	.281**	.323**	.331**
Defeat	.299**	.392**	.398**	.489**	.493**	.515**
Entrapment	.321**	.398**	.411**	.470**	.465**	.513**
Perfectionism	.158**	.202**	.195**	.204**	.202**	.239**
SNI-5 total	.328**	.413**	.436**	.505**	.514**	.546**

Notes: * p < .05, ** p < .01.

Table 6. The correlations of subscale scores between five-item Suicide Narrative Inventory (SNI-5) and five-item Suicide Crisis Scale (SCS-5).

	Entrapment	Affective disturbances	Loss of cognitive control	Hyperarousal	Social withdrawal	SCS-5
Perceived burdensomeness	.410**	.449**	.421**	.389**	.424**	.477**
Fear of humiliation	.304**	.273**	.315**	.304**	.343**	.352**
Defeat	.514**	.510**	.517**	.477**	.489**	.572**
Entrapment	.505**	.479**	.500**	.480**	.490**	.560**
Perfectionism	.234**	.205**	.225**	.241**	.226**	.258**
SNI total	.410**	.449**	.421**	.389**	.424**	.477**

Notes: ** p < .001.

Table 7. Linear regression analysis on one-week suicidal ideation by SNI-5.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Perceived burdensomeness	0.405					0.266
Fear of humiliation		0.181				-0.340
Defeat			0.372			0.164
Entrapment				0.346		0.109
Perfectionism					0.143	
R^2	0.164	0.033	0.138	0.120	0.020	0.200

Notes: 1. Dependent variable=last week suicidal ideation.
   2. The figures in the Table indicated the standardized coefficients.
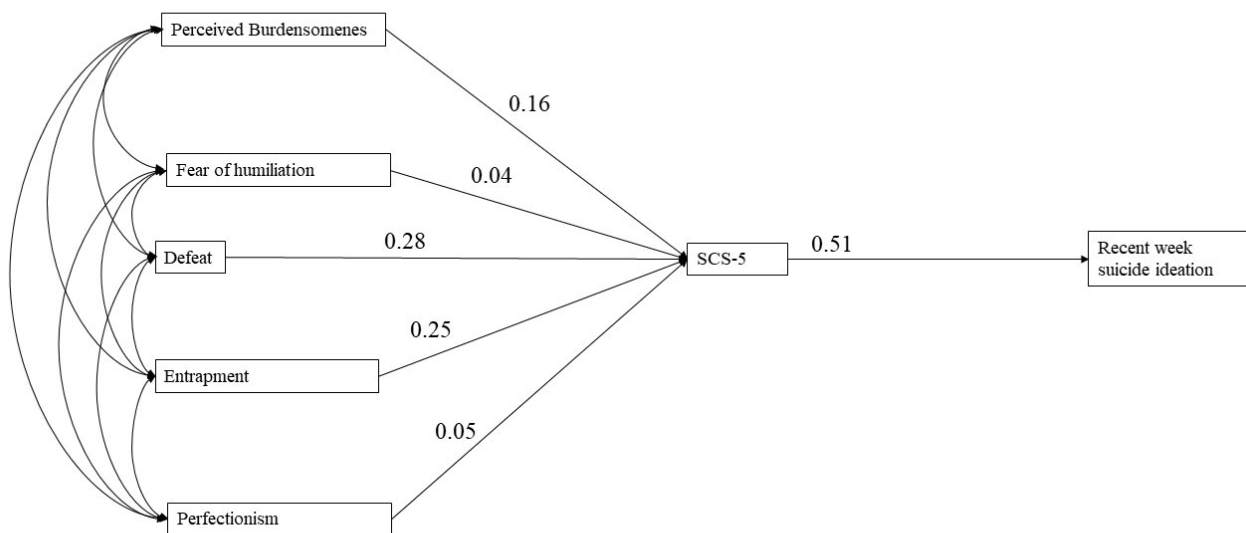   3. Model 1 to model 5 were conducted for individual variables and mode.

Figure 1. Path analysis on suicidal ideation by SCS-5 and SNI-5 items using structural equation model
(the values on the lines represent standardized regression coefficients).
The model fit statistics were as follows: Cmin/ Df = 48.93>5, p <0.001, CFI = 0.979> 0.9, AGFI = 0.922>0.9,
RMSEA =0.099 > 0.05).

ROC Curve

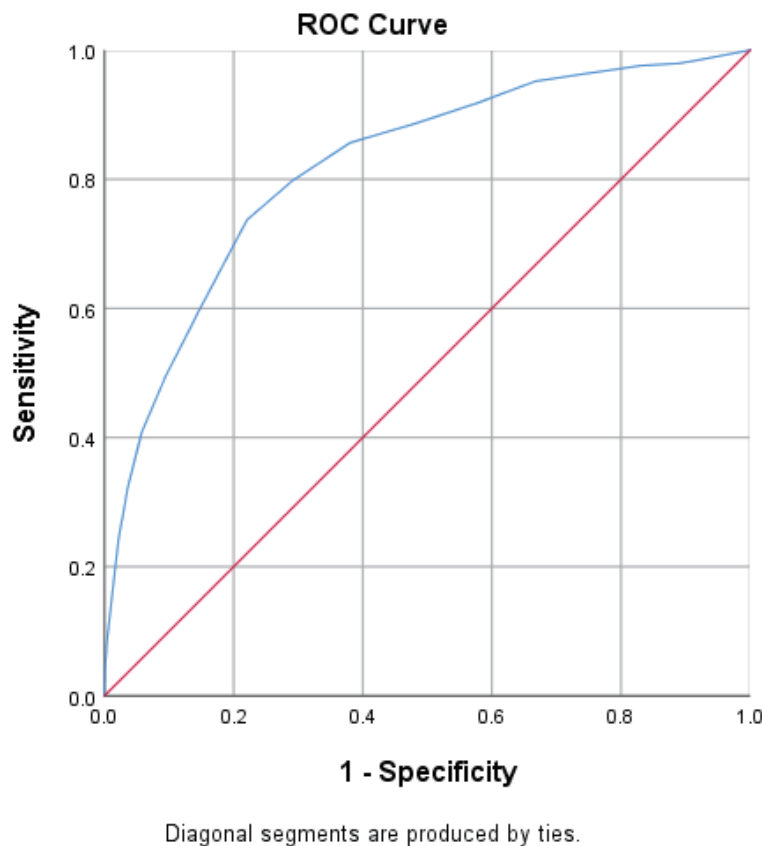Diagonal segments are produced by ties.

Figure 2. The sensitivity and specificity of Abbreviated SNI-5 to determine the recent suicidal ideation by ROC curve analysis with the area under curve (AUC=.820, 95% confidence interval=.802-.839; optimal cutoff=14, sensitivity=.798, specificity=.709 ; PPV=0.271, NPV=0.963).

Discussion

The major aim of the present study was to test the validity of the SNI-5 among the Taiwanese adult population. Consistent with our hypotheses, the SNI-5 fits the five-factor solution. It performed well with adequate internal consistency and significant convergent validity with existing valid measures (i.e., SCS-5, BSRS-5, lifetime SB, and SI in 1-week/1-month and lifetime) in our participants. Our finding suggested that the SNI-5 significantly correlated with recent week SI (.385) and certain subscales presented with higher correlations (e.g., perceived burdensomeness: 0.405; social defeat: .372 and entrapment: .346). On the other hand, perfectionism (.143) and fear of humiliation (.181) exhibited statistical significance but small correlations.

The association of burdensomeness, social defeat, and entrapment with suicide complied with the Interpersonal Theory [44] and the Motivational-Volitional model [45], respectively. The findings indicated that these two models worked together to provide a more significant figure of the interwoven factors. It was noted that perfectionism and fear of humiliation showed small associations with suicidality. These two variables were more attributed to the distal factors (i.e., personality trait and resilience) [46, 47], and so only small correlation with one-week SI was observed. Above all, social defeat,

entrapment, and perceived burdensomeness might be precipitated or triggered as subacute mental states by life stressors. Although perfectionism and fear of humiliation did not stand out as much to predict one-week SI, they might be possible important aggravating factors leading to suicidal behavior.

Our study found a moderate correlation (.545) between SNI-5 and general psychopathology measured by BSRS-5 (Table 3). In terms of inter-item correlation, out of the 5 items of BSRS-5, depression (.505) and inferiority (.514) presented the highest correlation with SNI-5, followed by hostility (.436) and anxiety (.413). Hostility has been reported to be positively correlated with perceived burdensomeness and contributes to suicidal ideation [48, 49]. Regarding the linear regression analysis, all the subscales of SNI-5 significantly explained 20% of the total variance of one-week SI. Perceived burdensomeness, in particular, could affect recent one-week SI independently (Table 7). Path analysis conducted with the SEM model showed that all 5 subscales of SNI-5 interacted with SCS-5 to affect recent one-week SI.

Our findings confirmed the Narrative-Crisis Model (NCM) that the suicidal crisis emerged from the dynamic interactions of trait vulnerability, the suicidal narrative, and the negative mental state of SCS. The suicidal

narrative focuses on the psychological distress associated with the specific life narrative of a suicidal individual. An increase in the SNI-5 intensity is a critical point leading to increased emotional distress, which further contributes to overall suicide risk [29, 30]. In clinical practice, the SNI-5 may represent an alternative to traditional suicide risk assessment relying on self-reported psychological distress or SI. Increasing evidence supported the use of indirect questions to explore an individual's feelings of entrapment and related cognitive-affective experience instead of formal disclosure of suicidal intent [29, 30]. Such indirect questioning may provide key insights into the underlying nature and extent of a suicidal crisis and direct appropriate crisis intervention measures. It is worthy testing if the combination of the SNI-5, SCS-5, and BSRS-5 with an additional item of suicidal ideation for the gatekeeper and aftercare for the suicide attempter could increase the predictive power to detect imminent suicidal risks [50].

Whether the SNI-5 is an accurate representation of the original framework of suicide narratives remained an issue for discussion. The original suicidal narrative contains eight distinct categories: 1) perceived burdensomeness, 2) thwarted belongingness, 3) defeat, 4) fear of humiliation, 5) goal reengagement, 6) goal disengagement, 7) entitlement to happiness, and 8) perception of no future. In comparison, the construct of the abbreviated SNI used in the I-SPARC contained the above-mentioned first six subscales and had the following shortcomings: 1) It does not include entitlement to happiness and perception of no future subscales. 2) It includes perfectionism, which is not a state but a trait (long-term vulnerability). 3) The goal-reengagement subscale is poor. In the study, only five subscale items instead of the full suicidal narrative were significantly selected. In particular, only three of those eight categories were represented by the SNI-5; the SNI-5 does not contain goal-orientation factors which was directly related to the SCS loss of cognitive control factor. Moreover, neither perfectionism nor entrapment are part of the suicidal narrative, though they were included in the original SNI (parent form of SNI-5). Basically, the excluded three items of the SNI were expressed as positive statements of protective factor but calculated as risk factors after reverse coding. Thus, SNI is an imperfect first measure of the Suicidal Narrative, which needs to be refined by adding the entitlement to happiness and the perception of no future factors. Perfectionism in the future should become a part of the "long-term vulnerability" scale also containing other NCM long-term vulnerabilities (pessimism, fearlessness, lack of moral objections to suicide, and history of mental illness and attempts). Otherwise, defeat and entrapment from the SNI have been consistently shown to be nearly overlapping and almost redundant constructs, so including these two but not other facets of the suicidal narrative needs further investigation in different populations.

Finally, the SNI is not theorized to form a higher-order construct and has repeatedly only demonstrated a good fit as a multidimensional construct (with no total score) of separate but related facets. This differs from the approach in the study and indeed the internal consistency of the resultant measure in this sample is only adequate (.77). The findings of the study just provided the basis for clinicians to conveniently integrate the Narrative-Crisis Model to treat individuals at risk of suicide.

Limitation

The online survey might recruit individuals more likely from higher socioeconomic status. The study was cross-sectional in nature and no conclusion could be drawn about the predictive validity of the SNI-5 for suicide behavior. Further study should examine the SNI-5 used in diverse settings or populations with different suicidality to test the generalizability of the results. Further studies should be conducted to confirm the findings among diverse individuals across cultures and settings.

Conclusions

The suicide narrative assessed by SNI-5 was significantly associated with psychological distress defined by BSRS-5 and SCS-5 as well as suicidality (i.e., SI in a week and lifetime and suicide attempt in lifetime). The findings provide an important basis for the use of SNI-5 to screen and intervene earlier the near-term suicide risk although it may not represent the original theoretic construct of SNI.

Acknowledgment

Competing interests

The authors declare that they have no conflict of interests.

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Appendix: Five-Item Suicide Narrative Inventory (SNI-5)

Please read the following statements and rate how true the statement is for you in the last month.
(1.very disagree; 2. disagree; 3. no idea; 4. agree; 5. very agree)

1. These days, the people in my life would be happier without me (perceived burdensomeness)

2. I demand nothing less than perfection of myself (perfectionism)

3. I feel powerless to change myself (entrapment)

4. I feel that my confidence has been knocked out of me (defeat)

5. I fear being bullied (fear of humiliation)

The Physical and Psychiatric Diagnoses before Suicidal Death in the Elderly: A National Population-Based Study in Taiwan from 2006 to 2015

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Abstract: *Background:* Suicide in older adults is an important public issue globally, but large-scale studies of the physical and mental diagnoses before suicidal death are lacking. The study aimed to reveal the medical diagnoses before suicidal death and estimate the trends of associated physical illnesses and mental disorders with suicide over the years. *Methods:* This was a national data linkage study. Cause of Death Data and the National Health Insurance Research Database (NHIRD) were used to collect the medical diagnosis of suicide patients within a year prior to death; a control group was paired by 10 times the amount. Logistic regression was used to calculate the odds ratios (ORs), and the ORs and prevalence were used to calculate the population attributable fraction (PAF) between two time periods of 2006 to 2010 and 2011 to 2015. The analysis were conducted in two groups of people: the outpatient and emergency service users and the inpatient service users. *Results:* Among out-patient and emergency service users, the diagnoses of suicide group ranking by PAF index from high to low were as follows: hypertensive disease (OR = 2.33, 95% CI = 2.19-2.46, PAF = 0.31), neurotic disorders & personality disorders (OR = 6.12, 95% CI = 5.74-6.53, PAF = 0.28), disorders of the eye and adnexa (OR = 2.17, 95% CI = 2.05-2.3, PAF = 0.25), gastric and duodenal ulcer (OR = 3.31, 95% CI = 3.10-3.53, PAF =0.19), and depressive disorders (OR = 10.58, 95% CI = 9.72-11.52, PAF = 0.18). The above ranking orders and the odds were similarly presented during 2011-2015 period. For inpatient diagnoses prior to suicide, malignant neoplasms and nephritis or other kidney diseases were two different diagnoses that distinct from outpatient/emergency group of patients. *Conclusions:* Our study is the first national data linkage analysis of medical diagnosis prior to suicide death in the elderly. The older adults with diagnoses of neurotic disorders & personality disorders, depressive disorders, cancer, renal disease, hypertensive disease, or pneumonia, are associated with an increased risk of suicide and need special attention.

Keywords: suicide, mental disorder, physical disease, National Health Insurance Research Database (NHIRD), elderly.

Introduction

According to the 2019 estimates from the World Health Organization (WHO), suicides caused over 700,000 deaths worldwide (representing about 1.3% of all deaths globally), making it the 17th leading cause of death in 2019 [1]. This Global Burden of Disease Study 2019 results revealed that suicide death rates increased with age and suicide mortality rates were almost three times higher in people aged 70 or older than in people under 70 (24.53 per 100,000 for ages greater than 70 and 14.25 per 100,000 between 50 and 69 years vs 11.19 per 100,000 between 15 and 49 years) [2]. The rates of suicide increase with age and reach their highest levels in the oldest age groupings and are sufficiently large for them to constitute a public health concern [3]. Therefore, suicide is one of the most critical public health concerns for the elderly [3-5]. Although suicide has dropped out of the top ten causes of overall death in recent years and the overall suicide rates did not change after the COVID-19 outbreak in Taiwan, suicide in older adults increased [6].

Suicide in older adults is strongly related to physical illnesses and mental disorders [3, 5, 7, 8]. Chronic illness and pain are crucial risk factors for suicidal behavior [9]. In a case-control study among older adults, physical health problems were present in 82% and felt to be contributory to death in 62% of the subjects [10]. Results of a systematic review on older adults (aged 65 and older) indicated that suicidal behavior is associated with functional disability and specific physical conditions, such as cancer, neurologic disorders, chronic obstructive pulmonary disease (COPD), liver disease, male genital disorders, arthritis/arthrosis, and pain [11]. A 37-year retrospective study confirmed the correlation between elderly suicidal behavior and somatic diseases, especially cancer and cardiovascular diseases, diagnoses that accounted over 45% of the cases studied [3]. Several recent reviews of the literature evidenced that suicide in the elderly is associated with cancer [12-14], dementia [15, 16], and chronic obstructive pulmonary disease (COPD) [17].

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Additionally, mental disorders are also related to suicide in the elderly [3, 7, 8, 18-22]. In older adults, suicide is often a consequence of mental disorders, such as depression, anxiety disorder, insomnia, Alzheimer's disease, and vascular dementia [18]. A recent review showed that depression and other mental health conditions, including schizophrenia, anxiety disorders, and perceived stress were predictors of suicide in the elderly [19]. Another systematic review suggested that the suicide risk in the elderly was related to depressive episode severity, psychiatric comorbidity (anxiety or substance use disorders), poorer health status, and loss of functionality [23]. Personality disorders were also associated with suicidal behavior in old age. A systematic literature review presented that maladaptive personality seemed to play a role in suicidal behavior and that obsessive-compulsive and avoidant personality disorders were implicated in death by suicide [24].

It is important for healthcare professionals and caregivers to be aware of these associations and to provide appropriate support, monitoring, and mental health care for elderly adults with significant physical health conditions and mental disorders. This study aimed to: (1) estimate the suicide risks of physical illnesses and mental disorders in the elderly; and (2) estimate the trends of physical illnesses and mental disorders with suicide over the years, in order to remind clinicians to pay attention to different clinical circumstances and design appropriate suicide prevention strategies.

Methods

Selection of subjects

We employed a registry-based prospective cohort design to determine the medical services utilization and diagnoses among suicide patients aged more than 65 years in Taiwan. Patient data for the suicide groups were obtained from the Cause of Death Data collected between 2006 and 2010, as well as between 2011 and 2015. To gather diagnosis codes and information on utilized services (out-patient departments, emergency departments, and in-patient departments) before death, we established a connection between the Cause of Death Data and the National Health Insurance Research Database (NHIRD) using a classification code, which replaced the national ID number in the system.

Data were collected within one year preceding the date of suicidal death. In the cases where patients made multiple visits during this one-year period, all visits were counted, and only the primary diagnosis for each patient was recorded. For the control group, we employed sex and birth year data as matching variables. Using a ratio of 1:10 (case: control), we searched the NHIRD using the date of death of the suicide group, aiming to ensure greater statistical power [25]. The paired subjects in the control group were either alive or had died due to non-suicidal causes. Identified by International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes, the diagnoses were categorized into 18 major categories and 24 sub-categories. A comprehensive list of all diagnosis was presented in Appendix 1.

Data source

The National Health Insurance (NHI) program in Taiwan provided comprehensive healthcare coverage to the vast majority of the population, with an enrollment rate of 99.8% of individuals enrolled [26]. The NHI claimed database, which included records for out-patient care, ambulatory care, and hospital in-patient care was maintained by the National Health Research Institute (NHRI). Established in 2000, the NHIRD served as a valuable source of healthcare information. The NHIRD encompassed demographic data, dates of clinical visits, diagnostic codes, and details of prescriptions. The Cause of Death Data, classified according to the ICD-9-CM and Tenth Revision ICD-10, included demographics and information on the cause of death, including deaths by suicide. To ensure compliance with the regulations of the Computer-Processed Personal Data Protection Law, all released data adhered to the necessary guidelines. The study obtained approval from the Institutional Review Board (IRB) with the reference number (NTUH-201204034RIC).

Statistical analysis

The comparison of prevalence rates of diagnoses between the suicide group and the control group in out-patient/emergency service departments and in in-patient populations was performed with odds ratios (ORs) with corresponding 95% confidence intervals (CIs) as well as the population attributable fraction (PAF). The PAF here was calculated as follows: (prevalence of risk factor in suicidal death) x (OR-1)/OR. PAF estimates the outcome proportion (suicidal death) in the population that would be reduced if the exposure (disease) were eliminated [27]. All analyses were performed using SAS 9.4.

Results

The comparisons of prevalence by diagnosis between suicide group and control group in out-patients and emergency services from 2006 to 2010 were presented with PAF and ORs in Table 1-1. In general, the top 10 diagnoses observed in the suicide group consisted of six physical diseases and four psychiatric disorders, with their prioritization based on the PAF. The rankings according to the PAF index from high to low were as follows: hypertensive disease (OR = 2.33, 95% CI = 2.19-2.46, PAF = 0.31), neurotic disorders & personality disorders (OR = 6.12, 95% CI = 5.74-6.53, PAF = 0.28), disorders of the eye and adnexa (OR = 2.17, 95% CI = 2.05-2.3, PAF = 0.25), gastric and duodenal ulcer (OR = 3.31, 95% CI = 3.1-3.53, PAF =0.19), depressive disorders (OR = 10.58, 95% CI = 9.72-11.52, PAF = 0.18), diseases of the ear and mastoid process (OR = 2.53, 95% CI = 2.36-2.7, PAF = 0.14) , cerebrovascular disease (OR = 2.57, 95% CI = 2.39-2.76, PAF = 0.12), bronchitis, emphysema, and asthma (OR = 2.28, 95% CI = 2.12-2.45, PAF = 0.11) neurotic depression (OR = 9.14, 95% CI =8.2-10.18, PAF =0.1), and episodic mood disorders (OR = 12.61, 95% CI = 11.2-14.2, PAF = 0.1).

The same comparison was conducted from 2011 to 2015, with their rankings based on the PAF in Table 1-2. The rankings according to the PAF index from high to low were as follows: hypertensive disease (OR = 2.31, 95% CI = 2.07-2.36, PAF = 0.32), neurotic disorders & personality disorders (OR = 5.74. 95% CI =5.35-6.15, PAF = 0.28), disorders of the eye and adnexa (OR = 2.17, 95% CI =2.04-2.31, PAF = 0.27), depressive disorders (OR = 10.58, 95% CI = 10.29 (9.42-11.23, PAF = 0.18), gastric and duodenal ulcer (OR = 2.92 , 95% CI = 2.72-3.14, PAF = 0.17), diseases of the ear and mastoid process(OR = 2.38, 95% CI = 2.21-2.55, PAF = 0.15), special symptoms or syndromes, not elsewhere classified (OR = 5.34, 95% CI =4.85-5.88, PAF = 0.12), neurotic depression (OR = 8.97, 95% CI 8.03-10.01, PAF =0.12), cerebrovascular disease (OR = 2.26, 95% CI = 2.1-2.45, PAF = 0.11), bronchitis, emphysema, and asthma (OR = 2.28, 95% CI = 2.12-2.45, PAF = 0.11) and episodic mood disorders (OR = 1.66, 95% CI = 1.55-1.77, PAF = 0.1).

Table 1-1. The comparisons of prevalence by diagnosis between suicide group and control group in outpatients and emergency services from 2006 to 2010.

	Control groups N=52190	Suicide groups N=5219	PAF	Odds Ratio
Hypertensive disease	1933	3015	0.31(0.29-0.33)	2.33 (2.19-2.46)
Neurotic disorders & Personality disorders	4306	1852	0.28(0.26-0.29)	6.12 (5.74-6.53)
Disorders of the eye and adnexa	16061	2563	0.25(0.23-0.26)	2.17 (2.05-2.30)
Gastric and duodenal ulcer	5805	1527	0.19(0.18-0.20)	3.31 (3.10-3.53)
Depressive disorders	1340	1138	0.18(0.17-0.19)	10.58 (9.72-11.52)
Diseases of the ear and mastoid process	6066	1301	0.14(0.13-0.15)	2.53 (2.36-2.70)
Cerebrovascular disease	4983	1112	0.12(0.11-0.13)	2.57 (2.39-2.76)
Bronchitis, emphysema, and asthma	5472	1100	0.11(0.10-0.12)	2.28 (2.12-2.45)
Neurotic depression	800	650	0.10(0.09-0.11)	9.14 (8.20-10.18)
Episodic mood disorders	553	621	0.10(0.09-0.11)	12.61 (11.20-14.20)

Note: Abbreviations: ORs, odds ratios; PAF, population attributable fraction.

Table 1-2. The comparisons of prevalence by diagnosis between suicide group and control group in outpatients and emergency services from 2011 to 2015.

	Control groups N=43580	Suicide groups N=4358	PAF	Odds Ratio
Hypertensive disease	18734	2724	0.32(0.30-0.34)	2.21 (2.07-2.36)
Neurotic disorders & Personality disorders	3939	1582	0.28(0.26-0.30)	5.74 (5.35-6.15)
Disorders of the eye and adnexa	15143	2336	0.27(0.25-0.29)	2.17 (2.04-2.31)
Depressive disorders	1327	1064	0.20(0.19-0.22)	10.29 (9.42-11.23)
Gastric and duodenal ulcer	5212	1237	0.17(0.16-0.19)	2.92 (2.72-3.14)
Diseases of the ear and mastoid process	6002	1199	0.15(0.13-0.16)	2.38 (2.21-2.55)
Special symptoms or syndromes	1476	687	0.12(0.11-0.13)	5.34 (4.85-5.88)
Neurotic depression	796	623	0.12(0.11-0.13)	8.97 (8.03-10.01)
Cerebrovascular disease	4840	961	0.11(0.10-0.13)	2.26 (2.10-2.45)
Diabetes	9000	1312	0.11(0.09-0.12)	1.66 (1.55-1.77)

Note: Abbreviations: ORs, odds ratios; PAF, population attributable fraction.

As for in-patients services, the comparisons of prevalence by diagnosis between suicide group and control group from 2006 to 2010 were presented with ORs and PAF in Table 2-1. The rankings according to the PAF index from high to low were as follows: hypertensive disease (OR = 4.51, 95% CI = 4.17-4.86, PAF = 0.15), diabetes (OR = 3.85. 95% CI = 3.5-4.24, PAF= 0.28), malignant neoplasms (OR = 6.52 , 95% CI =5.79-7.34, PAF = 0.07), gastric and duodenal ulcer (OR = 5.3, 95% CI =4.67-6.02, PAF = 0.05), nephritis, nephrotic syndrome, and nephrosis (OR = 7.67, 95% CI = 6.62-8.87, PAF = 0.05), depressive disorders (OR = 37.88, 95% CI =29.42-48.76) PAF = 0.05), diseases of the ear and mastoid process, special symptoms or syndromes, not elsewhere classified (OR = 5.34, 95% CI =4.85-5.88, PAF = 0.05), neurotic depression (OR = 8.97, 95% CI 8.03-10.01, PAF =0.05), cerebrovascular disease (OR =3.62, 95% CI = 3.2-4.09, PAF = 0.05), pneumonia (OR = 4.09, 95% CI = 3.6-4.65, PAF = 0.04), diseases of the circulatory system (OR = 4.77 , 95% CI =4.05-5.62, PAF = 0.03) and episodic mood disorders (OR = 48.53, 95% CI = 34-69.27, PAF = 0.03).

The same comparison was conducted from 2011 to 2015, with their ranking based on the PAF in Table 2-2. The rankings according to the PAF index from high to low were as follows: hypertensive disease (OR = 4.14, 95% CI = 3.84-4.48, PAF = 0.18), diabetes (OR =3.69. 95% CI =3.35-4.06, PAF = 0.1), malignant neoplasms (OR = 6.08, 95% CI = 5.4-6.85, PAF = 0.08), nephritis, nephrotic syndrome, and nephrosis (OR = 9.75, 95% CI = 8.49-11.19, PAF = 0.08), pneumonia (OR = 3.78, 95% CI = 3.34-4.27, PAF = 0.06), depressive disorders (OR =32.36 , 95% CI =25.13-41.66,PAF = 0.05), gastric and duodenal ulcer (OR = 4.63, 95% CI = 3.99-5.37, PAF = 0.04), episodic mood disorders (OR = 31.83, 95% CI =22.54-44.94, PAF = 0.03), neurotic depression (OR =28.94, 95% CI 20.15-41.55, PAF =0.02), and diseases of the circulatory system (OR = 3.46, 95% CI =2.83-4.24, PAF = 0.03).

The comparisons of population attribution fraction and odds ratio by diagnosis between suicide group and control group in out-patient and emergency services from 2006 to 2010 and from 2011 to 2015 were displayed in Table 3. The top five diagnoses by PAF ranking observed in the suicide group over two time periods consisted of hypertensive disease, neurotic disorders & personality disorders, disorders of the eye and adnexa, gastric and duodenal ulcer, and depressive disorders. The new top ten diagnoses observed in the suicide group during the period from 2011 to 2015 included special symptoms or syndromes, not elsewhere classified, and diabetes.

Table 2-1. The comparisons of prevalence by diagnosis between suicide group and control group in inpatients services from 2006 to 2010.

	Control groups	Suicide groups	PAF	Odds Ratio
	N=52190	N=5219		
Hypertensive disease	2940	1106	0.15 (0.14-0.16)	4.51 (4.17-4.86)
Diabetes	1750	615	0.08 (0.07-0.09)	3.85 (3.50-4.24)
Malignant Neoplasms	777	468	0.07 (0.06-0.08)	6.52 (5.79-7.34)
Gastric and duodenal ulcer	756	377	0.05 (0.05-0.06)	5.30 (4.67-6.02)
Nephritis, nephrotic syndrome, and nephrosis	444	322	0.05 (0.04-0.06)	7.67 (6.62-8.87)
Depressive disorders	78	280	0.05 (0.04-0.05)	37.88 (29.42-48.76)
Cerebrovascular disease	1069	367	0.05 (0.04-0.05)	3.62 (3.20-4.09)
Pneumonia	874	340	0.04 (0.04-0.05)	4.09 (3.60-4.65)
Diseases of the circulatory system	470	217	0.03 (0.02-0.04)	4.77 (4.05-5.62)
Episodic mood disorders	37	174	0.03 (0.02-0.03)	48.53 (34-69.27)

Note: Abbreviations: ORs, odds ratios; PAF, population attributable fraction.

Table 2-2. The comparisons of prevalence by diagnosis between suicide group and control group in inpatients services from 2011 to 2015.

	Control groups	Suicide groups	PAF	Odds Ratio
	N=43580	N=4358		
Hypertensive disease	3243	1089	0.18 (0.16-0.19)	4.14 (3.84-4.48)
Diabetes	1879	621	0.10 (0.08-0.11)	3.69 (3.35-4.06)
Malignant Neoplasms	822	456	0.08 (0.07-0.09)	6.08 (5.40-6.85)
Nephritis, nephrotic syndrome, and nephrosis	452	404	0.08 (0.07-0.08)	9.75 (8.49-11.19)
Pneumonia	1027	364	0.06 (0.05-0.06)	3.78 (3.34-4.27)
Depressive disorders	81	248	0.05 (0.04-0.06)	32.36 (25.13-41.66)
Gastric and duodenal ulcer	601	265	0.04 (0.04-0.05)	4.63 (3.99-5.37)
Episodic mood disorders	43	133	0.03 (0.02-0.03)	31.83 (22.54-44.94)
Neurotic depression	40	113	0.02 (0.02-0.03)	28.94 (20.15-41.55)
Diseases of the circulatory system	381	129	0.02 (0.01-0.02)	3.46 (2.83-4.24)

Note: Abbreviations: ORs, odds ratios; PAF, population attributable fraction.

Table 3. The comparisons of population attribution fraction and odds ratio by diagnosis between suicide group and control group in outpatients and emergency services from 2006 - 2010 and 2011-2015.

	2006-2010		2011-2015	
	PAF	Odds Ratio	PAF	Odds Ratio
Hypertensive disease	0.31(0.29-0.33)	2.33 (2.19-2.46)	0.32(0.30-0.34)	2.21 (2.07-2.36)
Neurotic disorders & Personality disorders	0.28(0.26-0.29)	6.12 (5.74-6.53)	0.28(0.26-0.30)	5.74 (5.35-6.15)
Disorders of the eye and adnexa	0.25(0.23-0.26)	2.17 (2.05-2.30)	0.27(0.25-0.29)	2.17 (2.04-2.31)
Gastric and duodenal ulcer	0.19(0.18-0.20)	3.31 (3.10-3.53)	0.17(0.16-0.19)	2.92 (2.72-3.14)
Depressive disorders	0.18(0.17-0.19)	10.58 (9.72-11.52)	0.2(0.19-0.22)	10.29 (9.42-11.23)
Diseases of the ear and mastoid process	0.14(0.13-0.15)	2.53 (2.36-2.70)	0.15(0.13-0.16)	2.38 (2.21-2.55)
Cerebrovascular disease	0.12(0.11-0.13)	2.57 (2.39-2.76)	0.11(0.10-0.13)	2.26 (2.10-2.45)
Bronchitis, emphysema, and asthma	0.11(0.10-0.12)	2.28 (2.12-2.45)		
Neurotic depression	0.10(0.09-0.11)	9.14 (8.20-10.18)	0.12(0.11-0.13)	8.97 (8.03-10.01)
Episodic mood disorders	0.10(0.09-0.11)	12.61 (11.2-14.20)		
Special symptoms or syndromes			0.12(0.11-0.13)	5.34 (4.85-5.88)
Diabetes			0.11(0.09-0.12)	1.66 (1.55-1.77)

Note: Abbreviations: ORs, odds ratios; PAF, population attributable fraction.

Table 4 presented the comparisons of population attribution fraction and odds ratio by diagnosis between suicide group and control group in in-patient services from 2006 to 2010 and 2011 to 2015. The top five diagnoses by PAF ranking observed in the suicide group in inpatient services from 2006 to 2010 were hypertensive disease, diabetes, malignant neoplasms, gastric and duodenal ulcer, and nephritis, nephrotic syndrome, and nephrosis. During the 2011 to 2015 period, the top five diagnoses by PAF ranking observed in the suicide group in in-patient services were hypertensive disease, diabetes, malignant neoplasms, nephritis, nephrotic syndrome, and nephrosis, and pneumonia. The new top ten diagnoses by PAF ranking observed in the suicide group during the 2011 to 2015 period was neurotic depression.

Table 4. The comparisons of population attribution fraction and odds ratio by diagnosis between suicide group and control group inpatients services from 2006 - 2010 and 2011-2015.

	2006-2010		2011-2015	
	PAF	Odds Ratio	PAF	Odds Ratio
Hypertensive disease	0.15 (0.14-0.16)	4.51 (4.17-4.86)	0.18 (0.16-0.19)	4.14 (3.84-4.48)
Diabetes	0.08 (0.07-0.09)	3.85 (3.50-4.24)	0.10 (0.08-0.11)	3.69 (3.35-4.06)
Malignant Neoplasms	0.07 (0.06-0.08)	6.52 (5.79-7.34)	0.08 (0.07-0.09)	6.08 (5.40-6.85)
Gastric and duodenal ulcer	0.05 (0.05-0.06)	5.30 (4.67-6.02)	0.04 (0.04-0.05)	4.63 (3.99-5.37)
Nephritis, nephrotic syndrome, and nephrosis	0.05 (0.04-0.06)	7.67 (6.62-8.87)	0.08 (0.07-0.08)	9.75 (8.49-11.19)
Depressive disorders	0.05 (0.04-0.05)	37.88 (29.42-48.76)	0.05 (0.04-0.06)	32.40(25.13-41.66)
Cerebrovascular disease	0.05 (0.04-0.05)	3.62 (3.20-4.09)		
Pneumonia	0.04 (0.04-0.05)	4.09 (3.60-4.65)	0.06 (0.05-0.06)	3.78 (3.34-4.27)
Diseases of the circulatory system	0.03 (0.02-0.04)	4.77 (4.05-5.62)	0.02 (0.01-0.02)	3.46 (2.83-4.24)
Episodic mood disorders	0.03 (0.02-0.03)	48.53 (34-69.27)	0.03 (0.02-0.03)	31.80(22.54-44.94)
Neurotic depression			0.02 (0.02-0.03)	28.90(20.15-41.55)

Note: Abbreviations: ORs, odds ratios; PAF, population attributable fraction.

Discussion

To our knowledge, the study presented the national data linkage analysis of medical diagnosis prior to suicide death among elderly adults. Among the out-patient and emergency departments, hypertensive diseases were the highest-ranking diagnoses of the suicide group by PAF, followed by relatively equal number of physical diseases and mental disorders. Among the in-patient services, hypertensive diseases were also the highest-ranking diagnoses by PAF, followed by more physical diseases and fewer mental disorders. The findings were different from our previous studies among general population and young adults, in which mental disorders were the most common diagnoses in out-patient services, emergency departments, and in-patient services [28, 29]. This difference is partially due to age group differences and partially due to using PAF as the ranking sequence rather than OR. Ranking by odds ratio in the study, mental disorders were the most common diagnoses in out-patient services, emergency departments, and in-patient services among elderly adults.

Population Attributable Fraction (PAF) for suicide prevention related to physical illnesses or mental disorders refers to the proportion of suicides in a population that could potentially be prevented if specific physical health conditions or mental disorders were effectively treated or eliminated [27]. This measure helps to understand the impact of physical health and mental disorders on suicide risk at the population level. Our study showed that certain physical illnesses, such as cancer (OR = 6.08, 95% CI = 5.4-6.85, PAF = 0.08), renal disease (OR = 9.75, 95% CI = 8.49-11.19, PAF = 0.08), hypertensive disease (OR = 4.14, 95% CI = 3.84-4.48, PAF = 0.18), and pneumonia (OR = 3.78, 95% CI = 3.34-4.27, PAF = 0.06) were associated with an increased risk of suicide, and that calculations of the PAF would estimate the number of suicides that could potentially be prevented if these specific physical conditions were adequately managed or prevented.

As reported by a previous study, physical conditions and multi-physical morbidities increased with age among older adults [30]. In the United States, older suicide descendants, with and without physical problems as a suicide precipitant, were compared [31]. Physical health problems were recorded as a suicide precipitant for 50% of the older descendants. Compared to their counterparts, those with physical health problems as a precipitant were older and more likely to have had depressed mood. In a large Danish register-based cohort study, the association between 39 physical diseases and death by suicide in older adults (aged 65 years and older) was examined from 1990 to 2009. Increased suicide risk was reported among different types of cancer (lung, gastrointestinal, breast, genital, bladder, lymph node), cerebrovascular diseases, heart diseases, COPD, gastrointestinal disease, liver disease, epilepsy, arthritis, osteoporosis, prostate disorders, male genital disorders, cataract, and spinal fracture, when compared to individuals not diagnosed within three years [32]. This might be consistent with our results that cancer, hypertensive disease, and cerebrovascular diseases showed a higher suicide risk among the physical illnesses in older adults. However, our study did not examine the subcategories of each cancer diagnosis. Further study on the association between suicide death and subtypes of cancers among the elderly is indicated.

Our study showed that mental disorders among older adults had high suicide risks, including neurotic disorders & personality disorders, depressive disorders, neurotic depression, and episodic mood disorders. The finding is consistent with previous studies [18-21, 23]. Among these disorders, depression is frequently underdiagnosed and undertreated in older adults [33]. Therefore, an intensive assessment in older adults with depression to target suicide and to monitor suicide behavior was warranted as a key indicator of depression treatment success [23].

A systematic review and a meta-analysis of record linkage studies restricted to older people showed that the pooled risk ratio was 17.3 for psychotic disorders, followed by 12.7 for mood disorders and 9.4 for personality disorders [34]. In our study, psychotic disorder was not ranked within the top 10 diagnoses by PAF ranking. This might be attributed to the special care program with early treatment and long-term community follow-up of schizophrenia patients in Taiwan. In addition to home care programs, chronic wards and daycare units both provided good standards of care, which might decrease their suicide risk [28,35,36]. In regards to personality disorders associated with suicidal behavior in old age, our study results showed prominent prevalence with PAF 0.28 (0.26-0.3) and OR 5.74 (5.35-6.15) in out-patient services and emergency services. Previous systematic review presented that obsessive-compulsive and avoidant personality disorders were implicated in death by suicide among the elderly [24]. However, our study combined neurotic disorders with personality disorders in one diagnosis category and did not distinguish between different types of personality disorders. As we know, these two categories are completely different disease diagnoses and may even have comorbidities. The association of suicidal death among older adults with different subtypes of personality disorders requires further study.

Comparing the two time periods (from 2006 to 2010 and from 2011 to 2015), the PAF and OR by diagnosis between suicidal group and control group were relatively similar in out-patient services and emergency services. However, in in-patient services, nephritis, nephrotic syndrome and nephrosis had higher PAF (from 0.05 to 0.08) and OR (from 7.67 to 9.75). Patients with diagnoses of nephritis, nephrotic syndrome, and nephrosis might have end-stage renal disease (ESRD), which had high suicide risks. A cohort study of 64,000 patients with end-stage renal disease receiving dialysis in Taiwan found that the suicide rate was 40% higher than the average [37]. Since patients with chronic kidney disease were among the groups with increased risk of suicide particularly in old age, suicide prevention strategy warrants more attention [38].

Limitations of the study

Our study contributed with addressing both physical and mental health aspects of suicidal death in the elderly. Data on the prevalence of these disorders can help in planning policies and strategies to prevent suicide in older adults [39,40]. However, the study had some limitations. First, although the sample size was large, important demographic variables, such as sex, age, educational level, and socioeconomic status, were not included in the analysis. An analysis using global suicide mortality and population data showed the impacts of different demographic data on suicidal death [41]. Second, the study included repeated visits before death; however, the number of these visits by each patient was not analyzed. Additionally, whether the patient had a chronic condition requiring regular visits or just a specific diagnosis was not taken into account. Third, the study analyzed the impacts of physical illnesses and mental disorders on suicide, but both of their comorbidities were not analyzed. A previous study showed that up to 20% of suicide death patients had physical disease comorbidities [42]. Fourth, since the diagnosis alone might not adequately give the complete picture of each patient, some researchers of the NHIRD have tried adding medication data [43]. Finally, considering the small amount of data collected by emergency departments, the analysis combined out-patient services and emergency data, potentially introducing ambiguity regarding the severity of mental disorders or physical illnesses.

Conclusions

In conclusion, our study is the first national data linkage analysis of medical diagnosis prior to suicidal death in the elderly. The study showed that mental disorders among older adults had high odds ratios of suicide, including neurotic disorders & personality disorders, depressive disorders, neurotic depression, and episodic mood disorders. Certain physical diseases such as cancer, renal disease, hypertensive disease, or pneumonia were associated with an increased risk of suicide by population attributable fraction ranking. By understanding the contribution of different risk factors to suicide among older adults, public health interventions and policies can be directed towards addressing the most significant factors, potentially leading to more effective suicide prevention efforts.

Acknowledgments

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Appendix: The diagnoses and ICD-9-CM code

Diagnosis	ICD-9-CM code
Malignant Neoplasms	140-208
Diabetes	250
Neurotic disorders and Personality disorders	300,301
Dementias	290
Alcohol-induced Mental disorders	291
Schizophrenic disorders	295
Episodic mood disorders	296
Delusional disorders	297
Neurotic disorders	300
Neurotic depression	3004
Personality disorders	301
Alcohol dependence syndrome	303
Special symptoms or syndromes, not elsewhere classified	307
Acute reaction to stress	308
Adjustment reaction	309
Depressive disorders	2962,2963,3004,311
Diseases of the nervous system and sense organs	320-389
Disorders of the eye and adnexa	360-379
Diseases of the ear and mastoid process	380-389
Diseases of the circulatory system	390-459
Hypertensive disease	401-405
Cerebrovascular disease	430-438
Diseases of the respiratory system	460-466,470-478,480-519
Bronchitis, emphysema, and asthma	490-493
Pneumonia	480-486
Diseases of the digestive system	520-579
Gastric and duodenal ulcer	531-533
Nephritis, nephrotic syndrome, and nephrosis	580-589
Diseases of the skin and subcutaneous tissue	680-709
Diseases of the musculoskeletal system and connective tissue	710-739
Injury and poisoning	800-999,E800-E999
Factors influencing health status and contact with health services	V00-V82

Suicidality and Psychological Distress among Caregivers of Chronic Patients: A Cross-Sectional Questionnaire Study

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Abstract: *Background:* As the number of homicide-suicides in families with long-term care needs increased in Taiwan, the psychological well-being and suicide risks of chronic patients' caregivers deserve more attention. *Methods:* The Taiwan Suicide Prevention Association performed a questionnaire survey using convenient sampling during April and October in 2021. The collaborating hospitals and institutions invited caregivers of chronic patients to provide informed consent and participate in the online survey. *Results:* The results revealed that over half of the caregivers were mentally distressed (over six points of the scale of mood thermometer) or diagnosed with any illness, and 12.5% had moderate to severe suicidal ideation. The most needed resources were home care, temporary and short-term care services respectively, with nearly 40% of caregivers expressing a need for these resources. The next in line were daytime care facilities, social welfare services, or economic assistance; each had around 30% of caregivers expressing a need. Approximately 20% of caregivers indicated a need for psychiatric/mental health care. *Conclusions:* These results were discussed in the study in terms of their implications for long-term care policy or suicide prevention strategies. It is essential to implement and further evaluate the effectiveness of these strategies in order to enhance suicide prevention efforts among caregivers of chronic diseases.

Keywords: caregivers, chronic patients, suicidality, psychological distress.

Introduction

The transition into the role of a family caregiver often occurs unconsciously and gradually. However, the caregiving journey can last up to 9.9 years [1], during which both the care recipient and the caregiver undergo changes that need to be addressed. Yet, if there isn't enough awareness throughout the process of adapting to these changes, caregivers may find themselves seeking the necessary support or resources every day. It is only when the accumulated burden becomes overwhelming that caregivers feel a sense of helplessness, isolation, and despair, and even entertain thoughts of violence, mutual destruction, or suicide.

As of December 2022, the elderly population in Taiwan has reached 17.56% of the total population, marking it as an "aging society" [2]. Through the joint efforts of the government and civil society, the "Long-term Care Services Act" was announced by the President in 2015, serving as a fundamental law for the development of long-term care in our country. This act aims to integrate various long-term care resources related to over 700,000 disabled families, ensuring comprehensive and well-connected resources to guarantee the quality of various long-term care services [2].

From 2017 to 2026, the Ministry of Health and Welfare has been actively promoting the Ten-Year Long-term Care 2.0 Plan [3]. The goal of this plan is to support the local aging population by providing a comprehensive range of services, including family support, home care, community-based care, and residential care. The aim is to establish care-oriented communities and ensure the accessibility of care services, ultimately enhancing the quality of life for individuals with long-term care needs and their caregivers. Current long-term care needs assessments cover both individual cases and primary family caregivers (referred to as caregivers). Through a process of screening, assessment, home visits, and the development of care plans, interventions are implemented and connections to various long-term care resources are established. Ongoing evaluations and follow-ups allow for adjustments to the care plans based on individual circumstances. It is important to note that family caregivers face multiple burdens, including physical, psychological, occupational, social, financial, and family relationship challenges. Therefore, in addition to addressing the care needs and health conditions of the individuals they serve, long-term care professionals also need to address their own life pressures.

Depression and anxiety pose a significant risk for suicide, which is deeply concerning when caregivers feel overwhelmed [4,5]. Such imbalances can further escalate the risk of suicidal thoughts. A study by Park et al. [6] involving 897 family caregivers of cancer patients revealed that the prevalence of suicidal ideation among caregivers within a year was 17.7%, of which the

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prevalence of suicide attempts was 2.8%. These rates surpassed those of the general population, hospitalized patients, and even cancer patients. Moreover, family caregivers dealing with anxiety or depression face a fivefold higher risk of suicide compared to the general population. Among caregivers experiencing anxiety or depression, certain factors associated with suicide risk were identified, including being female, unmarried, unemployed during the caregiving period, and reporting lower overall quality of life.

Resilience serves as a protective factor for caregivers' mental well-being. Lin and Lin (2019) summarized relevant literature and identified the following characteristics of caregiver resilience [7]: (1) possessing positive personal traits such as optimism, humor, and adaptability; (2) being willing to communicate and prioritize problem-solving; (3) having a strong support network. Resilience can also be enhanced through various means. For example, in a study conducted in Thailand, a guided self-help manual based on cognitive-behavioral therapy (CBT) was used as a bibliotherapy intervention, resulting in improved resilience for both depression patients and their caregivers [8]. Another study by Gibbons et al. (2019) focusing on cancer patients and their caregivers found that role adjustment and mutual relationships contributed to enhancing dyadic resilience, benefiting both parties throughout their cancer journey [9].

This study aims to understand the mental and physical health profiles and underlying needs of the primary service recipients in the long-term care system. It examines four dimensions as follows:

(1) stress and burden experienced by primary caregivers,
(2) impacts on their mental and physical health and daily lives,
(3) protective factors for their psychological well-being,
(4) the risk of suicide.

The study seeks to explore these aspects comprehensively to gain insights into the primary service recipients' well-being and potential areas of support within the long-term care system.

Methods

Resource linkage collaboration

Organizer: Taiwan Suicide Prevention Society Collaborating Units: Department of Mental and Oral Health, Ministry of Health and Welfare; Department of Long-term Care, Ministry of Health and Welfare; East Jet Information Services Co., Ltd.

Organizational establishment and literature review

To begin, experts and scholars from various fields including psychiatry and nursing, suicide prevention,

social work and social services, long-term care, elderly welfare, and epidemiology were brought together for in-depth analysis and discussion. The focus was on exploring the current status of long-term care, caregiver burden, and its impact on mental and physical well-being, as well as examining the needs and connections to available resources. Through these discussions, the direction of the project was determined to be a combination of questionnaire surveys and database linkage analysis. This approach aimed to gain insights into the current situation of caregivers in the country. Furthermore, appropriate data analysis methods were devised, and the team conducted a comprehensive literature search based on recommendations from experts and scholars. The literature search covered topics such as long-term care suicide, elderly suicide, suicide prevention strategies, and risk factors. After a careful selection process, the team thoroughly reviewed the chosen literature. This further facilitated the consolidation of information and enabled the execution of data collection for subsequent analysis.

Questionnaire survey

(1) After the association's initial design of the caregiver survey, the content was revised based on recommendations from experts and scholars, aligning it with the items from caregiver assessment scales. The survey was conducted using both paper-based and online methods.

(2) The questionnaire content includes basic information about the primary caregiver, disability category and ICD diagnosis of the care recipient, relationship with the care recipient, background information on caregiving, mood assessment, physical health status, self-assessment of mental health, and help-seeking behavior.

(3) Data collection
The survey was conducted from April to October 2021 using both Google Forms and paper questionnaires simultaneously.

a. Source of participants: Primary caregivers from organizations including the Family Caregiver Support Association of the Republic of China, New Taipei City Family Caregiver Care Association, Kaohsiung City Family Caregiver Care Association, Hongdao Elderly Foundation, Eden Social Welfare Foundation, and Bali Sanatorium in New Taipei City.

b. Data Description: Survey on the physical and mental health needs of primary caregivers for long-term care cases.

c. Data Content: The data primarily includes information on socio-demographics, caregiving work and background, physical and mental health status, and help-seeking behavior.

Results

Socio-Demographic characteristics (Table 1)

A total of 137 questionnaires were collected (129 valid questionnaires), analyzing various socio-demographic variables. The majority of respondents were female, accounting for nearly 80% of the sample. The average age was 55.9 years, with almost 60% being middle-aged caregivers between 46 and 64 years old. Caregivers aged 65 and above represented approximately one-fourth of the sample. In terms of education, the majority had a high school or vocational education, followed by some with associate's degrees.

Regarding marital status, over half of the caregivers were married/cohabitating, followed by singles. In terms of religious beliefs, the majority identified as Christian/Catholic or other, with Buddhism being the second most common, and 15.5% of caregivers reported having no religious affiliation. In terms of employment, nearly 50% of the caregivers were unemployed, around 35% were employed, and the remaining were homemakers. The majority of respondents (70%) lived in the northern region. In terms of annual household income, the highest proportion was below 350,000 NT dollars, followed by 350,000-650,000 NT dollars. Caregivers generally perceived their economic situation as slightly unfavorable. Additionally, one-fourth of the caregivers themselves had a disability certificate.

Table 1. Socio-Demographic characteristics of the caregivers of chronic diseases (N=129).

	n (%)/ Mean ± SD
Gender	
Male	29 (22.7)
Female	100 (77.3)
Age	55.9±12.3
23-46	22 (17.1)
46-64	75 (58.1)
65 and above	32 (24.8)
Education	
High School and below	59 (45.8)
University	55 (42.6)
Master and above	15 (11.6)
Marital status	
Single	38 (29.5)
Married/Cohabiting	72 (55.8)
Divorced/Separated/ Widowed	19 (14.7)
Religious beliefs	
Buddhism	38 (29.5)
Taoism/Traditional beliefs	27 (20.9)
Christianity/ Catholicism and others	44 (34.1)
None	20 (15.5)
Employment status	
Employed	44 (34.1)
Unemployed	64 (49.6)
Homemaker	21 (16.3)
Residential area in Taiwan	
Northern region	91 (70.5)
Other regions	38 (29.5)
Household annual income (n=122)	
Below 350,000	46 (37.7)
350,000-650,000	41 (33.6)
650,000-910,000	18 (14.8)
Above 910,000	17 (13.9)
Perceived economic status (1~5*)	2.67±0.83
Care recipients with disability^	33 (25.6)

Notes: *Scores: 1 Very poor, 2 Poor, 3 Average, 4 Good, 5 Very good.
^ The care recipient means people who received care from the caregivers.

Caregiver and care recipient background information (Table 2)

Care recipient disability categories and ICD diagnoses

The most common diagnosis among care recipients is neurological and psychological functioning impairments, with nearly 80% of care recipients having this diagnosis. The next most common diagnosis is ICD-Other, followed by neurological, muscular, and skeletal impairments and related functional limitations, speech and language impairments and related functional limitations, and developmental delay.

Caregiver and care recipient relationship (Table 3)

Over half of the caregivers hold the role of a younger generation, with daughters being the most common, accounting for a quarter of the total, followed by sons. The second largest category is elder caregivers, with mothers being the most common, followed by fathers. About one in five people are of the same generation, with spouses making up the majority.

Caregiver background information (Table 4)

Analyzing the caregiver's caring experience shows approximately 65% of caregivers have been providing care for over six years, followed by those who have been caregiving for one to three years. Regarding the time dedicated to caregiving, caregivers spend an average of 6.2 days per week and 12.7 hours per day, indicating that caregiving is a significant long-term commitment and significantly impacts the caregivers' own lives.

More than 80% of caregivers live with the care recipients, and the average number of people living together in the household is 2.2. The available manpower for rotational caregiving is 1.0 person. Regarding the level of care required by the care recipients, 34% of caregivers stated that the care recipients cannot be left alone at home, followed by those who can be left alone for one to three hours. In this survey, 17% of caregivers also reported caring for other disabled family members or children under the age of three, with an average of 1.3 people being cared for.

Health status of the caregivers (Table 5)

To understand the mental health status of caregivers, we conducted a survey using the brief symptom rating scale (BSRS). The results showed that over half of the caregivers scored above six, and 12.5% of caregivers reported having suicidal thoughts with a score of two or higher. Additionally, the Brief Symptom Rating Scale was used to assess their mental health, and it revealed that 66% of caregivers had a total score of four or higher.

In terms of overall health, 50% of caregivers have been diagnosed with a specific illness, and they perceive their physical health to be average with an average score of 2.8 (on a scale of 1 to 5, where 1 is very poor and 5 is excellent). Similarly, their perceived mental health is also average with an average score of 2.9. Their confidence in managing their current health or illness status is rated at 68.3 out of 100.

Table 2. Categories of care recipients' disabilities and ICD diagnoses (N=121).

	n (%)	Rank
Disability Category		
Category 1: Neurological System Structure and Mental/Cognitive Functions	**96 (79.3)**	1
Category 2: Eye, Ear, Related Sensory Structures, Functions, and Pain	9 (7.4)	
Category 3: Involving Voice and Speech Structures and Functions	**16 (13.2)**	4
Category 4: Cardiovascular, Hematopoietic, Immune, and Respiratory System Structures and Functions	6 (5.0)	
Category 5: Digestive, Metabolic, and Endocrine System-related Structures and Functions	9 (7.4)	
Category 6: Genitourinary System-related Structures and Functions	6 (5.0)	
Category 7: Neurological, Muscular, Skeletal System-related Structures and Functions	**22 (18.2)**	3
Category 8: Skin and Related Structures and Functions	2 (1.7)	
Category 9: Rare Diseases	3 (2.5)	
Category 10: Other Categories	8 (6.6)	
Category 11: Developmental Delay	**10 (8.3)**	5
ICD Diagnoses		
G80(Cerebral Palsy Patients)	2 (1.7)	
S14、S24、S34(Spinal Cord Injury Patients)	1 (0.8)	
R40.2、R40.3(Vegetative State)	0	
Other	**35 (28.9)**	2

Notes: *Subcategories not specified.

Table 3. The caregivers' relations with their care recipients.

Relationship	n (%)	Rank
Younger generation	**68 (52.7)**	
Daughter	33 (25.6)	1
Son	25 (19.4)	2
Daughter-in-law	4 (3.1)	
Son-in-law	2 (1.6)	
Granddaughter	3 (2.3)	
Niece	1 (0.8)	
Same generation	**26 (20.2)**	
Spouse	20 (15.5)	4
Sibling	6 (4.7)	
Elder generation	**5 (27.1)**	
Mother	22 (17.1)	3
Father	11 (8.5)	5
Parents-in-law	1 (0.8)	
Maternal grandmother	1 (0.8)	

Table 4. The caregivers' background information.

	n (%)/ Mean ± SD
Caregiving experience (n=129)	
Less than 1 year	4 (3.1)
1-3 years	29 (22.5)
4-5 years	13 (10.1)
6 years or more	83 (64.3)
Average weekly care days	6.2±1.5
Daily care time range (in hours)	2-24
Average daily care time (in hours)	12.7±7.7
Living with the care recipient (n=127)	107 (84.3)
Number of cohabitants (excluding the caregiver) (n=126)	2.2±1.3
Simultaneously caring for other disabled family members or children under 3 years-old (n=121)	21 (17.4)
Total number(s) of care recipients	1.3±0.6
Alternative caregivers to take turns	1.0±1.0
Spare time for the caregivers to go outside (n=128)	
Not able to leave home (due to care burden)	43 (33.6)
Less than 1 hour	12 (9.4)
1 hour to less than 3 hours	35 (27.3)
3 hours to less than 6 hours	24 (18.8)
6 hours to less than 9 hours	4 (3.1)
9 hours or more	10 (7.8)

Table 5. Psychological health status of the caregivers.

	n (%)/ Mean ± SD
Brief Symptom Rating Scale (n=120)	
<6 Scores	57 (47.5)
≥6 Scores	63 (52.5)
BSRS_1_Insomnia	1.4±1.1
Not at all	29 (24.2)
A little bit	37 (30.8)
Moderately	35 (29.2)
Quite a bit	13 (10.8)
Extremely	6 (5.0)
BSRS_2_Anxiety	1.3±1.1
Not at all	34 (28.3)
A little bit	42 (35.0)
Moderately	27 (22.5)
Quite a bit	14 (11.7)
Extremely	3 (2.5)
BSRS_3_Irritability	1.4±1.1
Not at all	27 (22.5)
A little bit	38 (31.7)
Moderately	37 (30.8)
Quite a bit	12 (10.0)
Extremely	6 (5.0)
BSRS_4_Depression	1.2±1.1
Not at all	36 (30.0)
A little bit	42 (35.0)
Moderately	26 (21.7)
Quite a bit	12 (10.0)
Extremely	4 (3.3)
BSRS_5_Inferiority	0.9±1.1
Not at all	57 (47.5)
A little bit	33 (27.5)
Moderately	16 (13.4)
Quite a bit	13 (10.8)
Extremely	1 (0.8)
Suicidal ideation	0.5±0.8
<2 Scores	105 (87.5)
≥2 Scores	15 (12.5)
Not at all	85 (70.9)
A little bit	20 (16.7)
Moderately	10 (8.3)
Quite a bit	4 (3.3)
Extremely	1 (0.8)
Self-harm or suicide attempt, lifetime	24 (20.0)
Currently thinking about suicide in the future	13 (10.8)
Excessive drinking or long-term use of certain drugs, lifetime	8 (6.7)
No trustworthy person to confide in when feeling down	38 (31.7)
Caregivers' diagnosed illnesses, any (n=128)	64 (50.0)
Self-rated physical health (1~5*)	2.8±0.8
Self-rated mental health (1~5*)	2.9±1.0
Health-related self-efficacy (0~100)	68.3±21.3

Notes: *Scores: 1 Very poor, 2 Poor, 3 Average, 4 Good, 5 Very good.
      BSRS: The 5-item Brief Symptom Rating Scale.

Resource utilization and help-seeking behavior:

(Table 6)

Required resources

According to the responses of caregivers in this survey, the most needed resources are home care, temporary and short-term care services, with nearly 40% of caregivers expressing a need for these resources. The next in line are daycare facilities, social welfare services, or financial assistance, each with approximately 30% of caregivers expressing needs. Around 20% of caregivers indicated a need for psychiatric/mental health medical services. Nearly a quarter of caregivers indicated no need for resources.

Utilized resources (Table 7)

Upon analyzing the resources utilized by caregivers, the most commonly used resource is daycare facilities, with 38% of caregivers having utilized this option. Home care, temporary and short-term care services follow closely behind, with approximately 32% of caregivers having used these resources. Hospital visits, including both psychiatric/mental health departments (27%) and non-psychiatric departments (around 21%), were also utilized by a significant number of caregivers. Additionally, nearly 20% of caregivers reported utilizing social welfare or financial assistance resources.

Reasons for not utilizing needed resources (Table 8)

The survey also focuses on the reasons why caregivers have not utilized the necessary resources. Nearly 55% of caregivers expressed that they feel they can currently handle the caregiving responsibilities and do not require resources at the moment. The second most common reason is 23% of caregivers feel that the services provided by the resources do not meet their needs. Other reasons include high cost (18%), not knowing how to obtain or use resources (17%), inconvenient location (15%), and being too busy to seek external resources (15%).

Table 6. Required resources of the caregivers.

	n (%)	Rank
None	32 (24.8)	4
Medical - Psychiatry/Psychosomatic Medicine	26 (20.2)	5
Medical - Other specialties (non-psychiatric)	24 (18.6)	
Health promotion or healthcare consultation (e.g., Public Health Center, medical consultations)	19 (14.7)	
Psychological counseling/therapy (e.g., psychological clinics, community mental health centers)	24 (18.6)	
Social welfare services or economic assistance (e.g., housing subsidies, assistive devices, income support)	38 (29.5)	3
Legal assistance	17 (13.2)	
Special education schools	3 (2.3)	
Day care facilities	41 (31.8)	2
Residential care facilities (e.g., full-time accommodation, nursing homes, psychiatric care homes, elderly care centers)	21 (16.3)	
Home care, temporary, and short-term care services	50 (38.8)	1
Other	8 (6.2)	

Table 7. Care resources used by the caregivers.

	n %	Rank
None	22 (17.1)	
Hospital - Psychiatry/Psychosomatic Medicine	35 (27.1)	3
Hospital - Other specialties (non-psychiatric)	27 (20.9)	4
Clinic - Psychiatry/Psychosomatic Medicine	5 (3.9)	
Clinic - Other specialties (non-psychiatric)	13 (10.1)	
Public Health Center	15 (11.6)	
Community mental health centers	5 (3.9)	
Private psychological therapy/counseling resources	8 (6.2)	
Telephone or online counseling	11 (8.5)	
Social welfare or economic assistance	24 (18.6)	5
Legal assistance	6 (4.7)	
Special education schools	15 (11.6)	
Day care facilities	49 (38.0)	1
Residential care facilities (e.g., full-time accommodation, nursing homes, psychiatric care homes, elderly care centers)	6 (4.7)	
Home care, temporary, and short-term care services	41 (31.8)	2
Other	6 (4.7)	

Table 8. Reasons for not utilizing needed resources by the caregivers (N=126).

	n (%)	Rank
Inconvenient location	19 (15.1)	
High cost	22 (17.5)	3
Feeling confident of handling the situation and currently don't need it	69 (54.8)	1
Too busy and no extra time to seek external resources	19 (15.1)	
Services provided by the resources do not meet the needs	29 (23.0)	2
Don't know how to access or use the resources	21 (16.7)	
Others	11 (8.7)	

Discussion

Based on the results of this survey, the predominant caregivers are female, with a majority belonging to the middle-aged group. Additionally, one-fourth of the caregivers are elderly individuals aged 65 or above. Furthermore, it was found that 25.6% of this group holds disability certificates, and more than half of the caregivers reported having a confirmed diagnosis of a medical condition. Over half of the caregivers experienced mild or higher levels of emotional distress (BSRS≥6), and 12.5% of them had moderate or higher levels of suicidal ideation. These findings indicated that the caregivers may not be in good physical and mental health, yet they bear the burden of long-term caregiving. In terms of resource utilization, the main resources needed and utilized by caregivers are daytime care facilities and home care services, including temporary and short-term care. About 55% of caregivers believe they can still manage the caregiving responsibilities and therefore do not seek additional resources. Overall, these findings highlight the challenges caregivers face, including underlying health issues and the need for specific resources.

The primary caregivers' stress and burden

According to the definition in Article 3 of the Long-Term Care Services Act, primary caregivers refer to family members or relatives who provide regular care to disabled individuals within the family. Long-term caregiving often brings physical, psychological, social, and financial burdens to caregivers, affecting not only their well-being but also family relationships [10]. To further understand the nature of the burdens faced by caregivers, overseas researchers have developed assessment tools for investigation and research. The most commonly used tool is the Zarit Caregiver Burden Scale [11], which assesses caregivers' stress and burden in various dimensions such as physical health, mental health, financial status, and social life. Another tool developed by Robinson (1983) is the Caregiver Strain Index which investigates common stressful events in caregiving, including disrupted sleep, inconvenience in daily life, physical strain, limited social activities, family adjustment, disrupted personal plans, caregiving time allocation to other family members, emotional adjustment, frustration with the care recipient's behavior, concerns about the care recipient's changes, work adjustments, financial burdens, and unbearable caregiving stress [12]. This index was also used in the 2010 National Survey on Long-Term Care Needs and the social indicator statistics conducted by the Directorate-General of Budget, Accounting, and Statistics (DGBAS) in Taiwan.

Overseas studies have found a higher prevalence of suicidal ideation among caregivers of individuals with dementia [13,14]. Subsequent research has further revealed that caregivers of individuals with dementia commonly experience high levels of stress and symptoms of depression. Furthermore, compared to caregivers without suicidal ideation, those with suicidal ideation are more likely to experience significant anxiety, depression, feelings of loneliness, low self-efficacy,

low self-control, and poorer family support [13]. In addition, caregivers of individuals with cerebral palsy often experience psychological health problems such as depression, anxiety, and stress. Apart from factors such as the caregiver's health status, economic situation, and social support, the coping strategies employed by caregivers when faced with problems are also associated with their level of depression [15-17]. Studies conducted on caregivers of Alzheimer's disease and bipolar disorder patients have found that as the patient's functioning deteriorates or if they have a history of suicide attempts, would further increase the burden on caregivers, and their own health worsens [18,19].

The suicide prevention strategies for family caregivers can be categorized into three levels. These strategies include strengthening public awareness, symptom recognition (such as depression and anxiety), and connecting caregivers to appropriate resources.

Targeted strategy

Caregivers who have expressed suicidal ideation, have a suicide plan, or have engaged in suicidal behavior should be referred to medical professionals for effective treatment.

Selective strategy

Based on the principles of early detection and identification of suicide risk factors among caregivers (such as acute/chronic stress responses: mood disturbances), it is recommended to provide caregivers with mood screening and counseling services, and community neighborhoods can refer high-risk caregivers to mental health centers for early assessment. Hospitals can also refer high-risk caregivers to internal resources and mood screening programs to implement early screening and comprehensive assessment practices.

Comprehensive strategy

Emphasis on network collaboration and care support requires enhancing the linkage between relevant network units or interdisciplinary connections. The resource linkage and mutual coordination between the New Taipei City Family Caregivers Support Association, the New Taipei City Government Center for Family Violence and Sexual Assault Prevention, suicidal care visitors, and community care visitors serve as excellent examples. Particularly for comprehensive Strategy prevention, cross-network collaboration and referral to mental health resources for high suicide risk cases are important protective factors in subsequent stages. The current practices in this regard can serve as a reference. In terms of support services for family caregivers, strategic discussions should be developed with the assistance of experts and scholars to strengthen the linkage to mental health resources. Since high-risk cases often do not utilize long-term care resources, media reports should include the long-term care hotline "1966" and the family caregivers support hotline "0800-50-7272" to increase caregivers' accessibility to help resources.

Regarding the diagnosis in the emergency department for elderly individuals with mental illnesses, the primary target population consists of those with

psychotic disorders, personality abnormalities, and depression, while for non-mental illness conditions, the prevention strategy focuses on elderly individuals with gastric and duodenal ulcers, and cerebrovascular diseases. In terms of hospitalization diagnosis, the target population for mental illnesses is primarily individuals with depression and affective disorders, while for non-mental illness conditions, the emphasis is on elderly individuals with nephritis, nephrotic syndrome, renal degenerative diseases, and malignant tumors [4].

Due to the atypical symptoms often exhibited by elderly individuals with depression, staff within institutions must recognize other suicide risk factors in older adults. These factors include feelings of loneliness, weak social support, and the presence of multiple chronic diseases [20]. In addition, it is encouraged to implement regular use of mood thermometers in long-term care facilities and provide comprehensive training for staff members to serve as gatekeepers in suicide prevention. These measures coupled with early detection through tools such as mood thermometers and staff training programs [21,22] can help to identify suicide crises early. As for suicide prevention among caregivers, a study review reveals that depression remains a significant risk factor. The additional life stressors faced by caregivers also increase their susceptibility to mental illnesses [23]. Therefore, the establishment of the Family Caregiver Care Hotline by the Ministry of Health and Welfare is an important strategy to enhance social support for caregivers. In the future, it is hoped that there will be more research on domestic caregivers to explore suicide risk factors at the social and individual psychological levels, in order to develop comprehensive suicide prevention measures.

In terms of suicide prevention strategies, a systematic review of all relevant strategies before 2018 revealed that they mainly included interventions directly targeting residents and gatekeeper training. It was found that providing support to caregivers has a preventive effect on suicide. However, most of the prevention strategies lack direct evaluation of their effectiveness. Therefore, it is crucial to implement these strategies and further assess their effectiveness in order to improve suicide prevention efforts [21,23].

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The Trends of Demographics, Methods, and Causes of Suicide Attempts in a Nationwide Population-based Study over Seventeen Years in Taiwan

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Abstract: *Background:* The National Suicide Surveillance System (NSSS), launched in Taiwan in 2006, is a structured nationwide intervention program for people who survived their suicide attempts. The study examined the accumulated data of the NSSS from 2006 to 2022 to investigate the trends of the demographics, causes of attempt and suicide methods across seventeen years. *Methods:* We collected longitudinal dataset from the NSSS across 17 years and performed descriptive and correlational statistics. Suicide attempt reporting ratio was calculated through numbers of reported attempts (excluding death) dividing by suicide deaths numbers; gender ratios were counted via female to male ratio of suicide attempts. We further assessed the correlation between causes and methods of suicide by gender. *Results:* In total, 518, 174 reported attempts (65.05 % females) were recruited for analysis. Firstly, the number of attempts increased with years. The updated number of attempts in 2022 was 45,366, featuring the climbing attention by the public. The suicide attempt reporting ratios kept escalating with a range between 4.2 and 11.4, indicating the society's efforts of suicide reporting to the government as a whole. The females outnumbered the males in attempts by about 1.68-2.05 times, the gender ratios remained relatively steady over the years. A majority of attempts occurred in the young and middle-aged groups (i.e., 25-34, 35-44, and 15-24.) The increasing trend of the 15-24 group outnumbered the others and became the highest in the number of attempts since 2019. Secondly, solid/liquid substance (39.3-6-60.1%) or wrist cutting (24.2-31.7%) were the major methods. The decreasing trend of solid/liquid substance was accompanied by the increasing trend of wrist cutting, falling from height, and others. Moreover, emotional/relational issues or mental health problems/substance abuse were two main causes of attempts. The rates of overall causes were steady between 2013 and 2022. Finally, among the total 518,174 attempts, gender difference in presentation of suicide causes was observed as female predominance in emotional/relational problems (49.5% vs 35.7%) and the choice of solid/liquid substance (53.6% vs 43.0%); male predominance in work/economics and physical illnesses. *Conclusions:* The accumulated data from the NSSS indicated a comprehensive profile and trends of demographics and causes and method choice across the 17 years and provided an empirical basis for developing pertinent prevention strategies.

Keywords: suicide surveillance, suicide attempts, reason of suicide, causes of suicide, methods of suicide.

Introduction

Suicidal or self-injured behavior is a major health issue and strongly associated with subsequent suicide [1-4]. As compared to the general population, suicide attempters have 66 times the risk for further reattempt death during the year following their index attempt [5]. History of previous attempt has greater risk for a future fatal attempt than having mental disorders [2, 6-10]. In Taiwan, the central government began to launch a National Suicide Surveillance System (NSSS) in 2006 in response to a steady increase in suicide rates. The NSSS registers suicide attempters nationwide and provides pertinent follow-up care including counseling, psychoeducation and needed referral to mental health and social welfare services [8, 10-12]. The case reporting portal of the NSSS incorporates non-governmental organizations and hospitals, as well as governmental departments (i.e., health, police, law enforcement, fire administration, social welfare and education). The accumulated NSSS data revealed that 1) the structured program of the NSSS decreased suicides and delayed time to death for those reported attempters who remained susceptible to suicide; 2) male gender, using more lethal methods at the index attempt were significant risk factors for subsequent suicide death [10]; 3) the levels of psychological distress measured by the five-item Brief Symptom Rating Scale (BSRS-5) at the index episode could significantly predict the future non-fetal and fetal attempts in one year [13,14]. The study used NSSS data accumulated from January 2006 to December 2022 to analyze the profile of demographics and psychosocial characteristics of the nonfatal attempters across seventeen years.

Methods

The subjects and study procedure

The study cohort included all suicide attempters in Taiwan who were registered in the NSSS from 2006 to 2022. The NSSS program, approved by the ethics committee of the National Taiwan University Hospital (no. 201204034RIC), comprised an initial assessment shortly after an attempt, followed by sessions of brief aftercare counseling/visits either in person or through telephone contacts during the ensuing 3–6 months. Each individual was first contacted within 3 days of the index registration and then followed-up via a minimum of two contacts per month for at least 3 months. When an individual attempting suicide was identified by a healthcare professional or institution, he/she would be registered through the NSSS on-line reporting system within 24 hours. If an individual was identified by any of the other agencies (e.g., firefighters or police), he/she would be reported to the Department of and Health Welfare by fax or the on-line registration process. Data regarding demographic characteristics, causes and methods of suicide attempts were collected and analyzed through the structured report form.

Statistical analyses

Using accumulated dataset during the research period, we first examined descriptive features over major variables including demographic information (age/gender), causes and methods of suicide attempts. Then we assessed the correlation between causes and methods of suicide by gender. All the variables were displayed by year over 17 years. Finally, suicide attempt reporting ratio was calculated through numbers of reported attempts (excluding death) dividing by suicide deaths numbers; gender ratios were counted via female to male ratio of suicide attempts. All analyses were based on a statistical computing program written in the R software version 2.7.2 (R Foundation for Statistical Computing, Vienna, Austria). The significance level was set at .05.

Results

Upon analyzing the available variables of the NSSS by descriptive and correlational statistics, we derived with 6 tables that comprehensively presented the longitudinal trend of the dataset. Firstly, the numbers and demographic features of suicide attempters across 17 years (2006-2022) were revealed in Table 1 to Table 3. It is noteworthy that the number of attempts was on the increase year by year even under COVID-19, which was a contrast with the minor decreasing trend of suicide death numbers in the same period (2020-2022). The most updated number of suicide attempts in 2022 was 45,366 (Table 1), featuring the climbing attention by the public/reporting institutions mainly from hospitals and schools. The suicide attempt reporting ratios kept escalating with the ranges between 4.2 and 11.4, indicating the society's efforts of suicide reporting to the government as a whole.

Regarding the gender and age of the trend and distribution of the suicide attempts across the 17 years, Table 2 showed that females outnumbered the males in suicide attempt by about 1.68-2.05 times. This is right the contrary of completed suicide gender ratios. However, the ratios remained relatively steadiness over the years. On the other hand, the age ranges of suicide attempt revealed that the majority of the prevalence lied in the young and middle-aged groups including 25-34, 35-44, 15-24, respectively (Table 3). The increasing trends of the three age groups were evident, with the 15-24 group outnumbered the other two groups since 2018 and became the highest number of suicide attempt reports in the NSSS system since 2019. This finding is an alarm for both medical and educational institutions to investigate further the detailed reasons, risk factors, and solutions to change the trend.

Secondly, we analyzed the methods and reasons of suicide attempts across 17 years in Table 4 and 5 respectively. Clearly the two major methods for suicide attempters were solid/liquid substance (39.3-6-60.1%) or wrist cutting (24.2-31.7%) (Table 4). It is noteworthy that the decreasing trend of solid/liquid substance was accompanied by the increasing trends of wrist cutting, falling from height, and other methods (e.g., railway or car crash attempts, banging against the wall, etc.). While the soaring numbers of other methods of attempts were not common when individually analyzed, it highlighted that at least 10-15% of the attempts were accounted by these uncommon ways of self-harm that did not lead to deaths. Another alarming information was about the climbing rates of falling from height during 2021-2022 while COVID-19 hit Taiwan. The decreasing trend of solid/liquid substance is worth further studies to understand its reasons and changing patterns behind the numbers, as well as its associations with the increases on the suicide attempts made by jumping or other methods. Moreover, Table 5 revealed that emotional/relational issues or mental health problems/substance abuse were two main reasons of suicide attempts. The rates of overall reasons stabilized between 2013 and 2022, with 90% accounting for mental health and relational issues with an average 15% unknown reasons to be identified.

Finally, we conducted correlational analyses in Table 6 toward the whole suicide attempts totaled 518,174 people, where the causes and methods of suicide were presented with the associations by gender. While the male suicide attempters were slightly older than the female counterparts (mean-age: 42.1 vs 37.5), some items of the two analyses were gender-specific presented. For example, the cause of emotional/relational problems (49.5% vs 35.7%) and the method of solid/liquid substance (53.6% vs 43.0%) were more prevalent among females who attempted suicide than males; however, work/economics, physical illnesses, others or unknown causes were more prevalent among males, so were the methods of car-exhaust/ charcoal burning, hanging/suffocation, or other methods of suicide attempts.

Table 1. Number of suicide attempt reports and ratio of attempt/ death by year during 2006-2022.

Year	No of attempts reported	No of reported attempts excluding death (A)	No of death (D)	Ratio of A/D
2006	19,162	18,365	4,406	4.2
2007	23,031	22,025	3,933	5.6
2008	24,245	23,110	4,128	5.6
2009	25,813	24,426	4,063	6.0
2010	26,870	25,603	3,889	6.6
2011	26,183	24,897	3,507	7.1
2012	28,471	26,742	3,766	7.1
2013	28,083	26,340	3,565	7.4
2014	29,047	27,329	3,542	7.7
2015	29,914	28,169	3,675	7.7
2016	28,996	27,233	3,765	7.2
2017	30,619	28,617	3,871	7.4
2018	33,207	31,354	3,865	8.1
2019	35,324	33,358	3,864	8.6
2020	40,432	38,428	3,656	10.5
2021	43,469	41,271	3,585	11.5
2022	45,366	43,062	3,787	11.4

Table 2. Number of suicide attempt reports by year during 2006-2022.

Year	Male	Female	Total	Ratio of F/M
2006	6,392	12,769	19,161	2.0
2007	7,560	15,470	23,030	2.0
2008	8,058	16,186	24,244	2.0
2009	8,811	17,000	25,811	1.9
2010	9,171	17,699	26,870	1.9
2011	8,922	17,261	26,183	1.9
2012	10,030	18,440	28,470	1.8
2013	10,109	17,974	28,083	1.8
2014	10,530	18,517	29,047	1.8
2015	10,952	18,962	29,914	1.7
2016	10,801	18,195	28,996	1.7
2017	11,430	19,189	30,619	1.7
2018	12,325	20,882	33,207	1.7
2019	12,512	22,812	35,324	1.8
2020	13,767	26,665	40,432	1.9
2021	14,807	28,662	43,469	1.9
2022	15,205	30,161	45,366	2.0

Table 3. Number of suicide attempt reports by age groups during 2006-2022.

Year	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-
2006	143	3,841	5,423	4,682	2,711	955	778	613
2007	166	4,284	6,664	5,443	3,459	1,297	894	815
2008	206	4,106	7,182	5,798	3,616	1,533	972	820
2009	208	3,958	7,490	6,222	4,161	1,769	1,052	945
2010	255	3,886	7,538	6,486	4,465	2,035	1,132	1,061
2011	307	3,979	7,060	6,304	4,411	1,991	1,056	1,066
2012	275	4,150	7,534	6,991	4,745	2,300	1,233	1,239
2013	262	3,840	7,121	6,941	4,910	2,399	1,177	1,424
2014	363	4,039	6,799	7,303	5,152	2,613	1,326	1,438
2015	379	4,389	6,802	7,418	5,284	2,781	1,291	1,559
2016	371	4,368	6,399	7,093	4,992	2,772	1,439	1,555
2017	408	4,905	6,525	7,432	5,136	3,048	1,490	1,668
2018	826	6,352	6,598	7,624	5,189	3,213	1,634	1,756
2019	1,337	7,991	6,648	7,411	5,156	3,244	1,694	1,812
2020	2,382	10,659	7,226	7,802	5,190	3,284	1,855	1,945
2021	2,742	12,316	7,680	7,657	5,171	3,548	2,181	2,064
2022	2,684	12,955	8,526	7,513	5,407	3,557	2,447	2,203

Table 4-1. Methods of suicide attempts (%) by year during 2006-2022.

Year	Solid/liquid substance	Gas	Carexhaust or Charcoal burning	Hanging or suffocation	Drowning
2006	58.7	1.3	6.8	2.9	1.0
2007	59.7	1.4	7.1	3.1	1.3
2008	60.1	1.3	6.9	3.1	1.3
2009	57.6	1.0	7.6	3.4	1.5
2010	55.0	1.0	8.3	3.1	1.9
2011	54.3	0.8	6.8	3.3	1.9
2012	54.9	0.8	7.5	3.6	2.1
2013	56.0	0.7	6.3	3.8	2.3
2014	54.6	0.7	6.8	3.9	2.3
2015	53.9	0.7	6.6	3.6	2.2
2016	51.9	0.7	6.6	4.0	2.4
2017	50.5	0.7	6.8	4.5	2.7
2018	48.1	0.7	6.6	4.6	2.3
2019	46.7	0.5	6.1	4.7	2.6
2020	43.7	0.6	4.8	4.8	2.3
2021	40.4	0.5	4.4	5.0	2.9
2022	39.3	0.5	4.2	5.0	3.4

Table 4-2. Methods of suicide attempts (%) by year during 2006-2022.

Year	Guns and explosives	Wrist cutting	Falling from heights	Others
2006	0.2	24.2	2.4	8.3
2007	0.0	26.4	2.5	6.8
2008	0.0	26.6	2.4	7.7
2009	0.0	26.7	2.9	9.4
2010	0.0	26.7	3.4	11.4
2011	0.0	26.8	3.5	10.3
2012	0.0	26.6	4.1	10.2
2013	0.1	27.4	4.5	9.3
2014	0.1	26.9	5.0	10.1
2015	0.1	27.1	5.1	10.7
2016	0.1	28.5	5.6	8.7
2017	0.1	27.8	6.1	9.7
2018	0.1	29.5	6.8	10.1
2019	0.1	30.7	7.0	10.7
2020	0.1	32.8	7.6	13.1
2021	0.0	31.2	9.3	15.7
2022	0.1	31.7	11.0	15.2

Table 5. Causes of suicide attempts (%) by year during 2006-2022.

Year	Emotions / Relationships	Mental health/ substance abuse	Work/ economics	Physical disease	Campus/ workplace	Persecution	Others	Unknown
2006	35.7	24.8	8.5	4.5	0.6	0.0	42.3	0.1
2007	45.4	33.0	8.6	5.6	0.7	0.0	29.8	0.6
2008	48.8	37.6	10.5	6.3	0.8	0.0	18.3	8.0
2009	56.7	42.2	14.3	7.7	0.7	0.0	13.3	0.2
2010	58.1	42.1	12.7	8.5	0.7	0.0	13.1	0.0
2011	60.2	40.3	11.0	8.0	0.8	0.0	11.6	0.1
2012	57.1	41.7	12.4	9.1	0.9	0.1	10.1	4.5
2013	51.3	34.2	12.2	8.5	1.0	0.4	3.5	17.0
2014	49.9	27.2	11.5	7.9	1.2	0.5	3.3	17.1
2015	49.4	27.9	11.1	7.8	1.3	0.5	3.1	17.1
2016	47.0	35.4	9.9	7.4	1.5	0.6	5.1	17.0
2017	45.8	37.7	10.0	7.1	2.0	0.7	5.3	16.9
2018	46.2	40.9	10.7	7.2	3.0	0.8	5.8	14.7
2019	46.1	43.6	10.7	6.6	4.2	0.8	5.9	13.2
2020	46.0	45.8	10.4	6.8	5.9	1.0	6.7	12.1
2021	45.3	48.0	10.8	6.9	6.4	1.4	7.2	11.6
2022	44.6	50.2	10.8	7.2	6.6	1.6	7.3	11.2

Table 6. Causes and methods of suicide attempts by gender in 2006-2022.

		Female (N=336,769 , 65.0%) n (%)	Male (N=181,405 , 35.0%) n (%)	Total (N = 518,174) n (%)
Age		37.5±**0.03**	42.1±0.04	39.1±0.02
Cause of suicide	Emotions / Relationships***	198,813 (42.0)	78,472 (31.3)	277,285 (38.3)
	Mental health/ substance abuse***	151,019 (31.9)	71,155 (28.3)	222,174 (30.7)
	Work/Economics***	30,756 (6.5)	30,114 (12.0)	60,870 (8.4)
	Physical disease***	18,495 (3.9)	20,247 (8.1)	38,742 (5.4)
	Campus/workplace***	10,492 (2.2)	3,905 (1.6)	14,397 (2.0)
	Persecution***	2,692 (0.6)	640 (0.3)	3,332 (0.5)
	Others***	29,967 (6.3)	21,715 (8.7)	51,682 (7.1)
	Unknown***	31,090 (6.6)	24,787 (9.9)	55,877 (7.7)
Methods	**Solid/liquid substance***	196,702 (51.0)	86,147 (42.2)	282,849 (47.9)
	Gas***	1,386 (0.4)	2,577 (1.3)	3,963 (0.7)
	Car-exhaust or Charcoal burning***	13,424 (3.5)	19,174 (9.4)	32,598 (5.5)
	Hanging or Suffocation***	9,027 (2.3)	12,027 (5.9)	21,054 (3.6)
	Drowning***	7,040 (1.8)	4,707 (2.3)	11,747 (2.0)
	Guns and explosives***	42 (0.0)	267 (0.1)	309 (0.1)
	Wrist cutting***	110,218 (28.6)	40,179 (19.7)	150,397 (25.5)
	Falling from heights***	17,533 (4.5)	12,399 (6.1)	29,932 (5.1)
	Others***	30,629 (8.0)	26,917 (13.2)	57,546 (9.8)

Note: By chi-square test: ***$p<0.01$.

Discussion

This longitudinal population-based study of a large sample of suicide attempters registered in Taiwan suicide surveillance system provided a valuable reference for current knowledge of suicide prevention strategies. From early prevention perspectives, the gender and age differences among the suicide attempters reporting to central across the 17 years revealed the target populations for prevention and interventions. While the causes and methods of attempts were specific to certain gender, the age trend also drew much attention among the young and middle-aged groups. The reverse trend between methods of solid/liquid substance and jumping/ other methods of suicide attempts worth further investigations.

According to available psychosocial variables used in this study, the dataset reflected that suicide attempts was more prevalent among the middle-aged group, and its female-dominant characteristics was similarly found in a Korean study of a local sample mean-aged 33.4±15.9 of the females [15]. Compared to a population-based study in Iran, those aged between 20-40 years-old were the majority of suicide attempters, but males were slightly higher than the females (56.2% vs 43.8%) [16]. This could be partially due to different cultural context and the distinct female social status or stress perceptions under different cultures. The gender ratio of around two-times higher among females was of noted and should inform early prevention for suicide act or self-harm in young girls before happening. The markedly increasing trend of aged 15-24 outnumbered the other groups and became the highest number of suicide attempt reports in the NSSS since 2019. The major reason of this finding might be enactment of the Taiwan Suicide Prevention Act in 2019, in which suicide attempt notification extending from mental health workers in medical institutions to all individual health workers in any institutions including educational units and the reporting changed from "responsibility notification" to "statutory notification". Importantly, the finding reminds both medical and educational institutions to further collaborate to improve the trend.

Among all causes of suicide attempts in this study, emotional or relational problems were accountable for nearly 45% of the attempts comparing to one-fourth of substance or mental health illnesses. It can be inferred that suicide behaviors are highly associated with interpersonal issues under the Taiwanese or the Asian cultures in general. Moreover, mental health issues should be a prime target for suicide prevention at early stage of suicide behaviors [17], particularly in the cultural context or environmental risks that put higher burden on the person with suicide ideation. The other target of attention for suicide prevention is substance use, while our findings supported the view that drug-specific disorders are most highly associated with the likelihood of suicide attempt [18]. Our findings further pointed out that both biological males/females were equally affected by substance or other mental health problems. Previous study also showed the strong correlation between debt burden and suicide attempt in a large epidemiological survey [19], indicating that environmental factor is a significant risk to suicidal behavior.

Regarding the methods of suicide attempt, the results found in this study was primarily focusing on the non-fatal attempt rather than completed suicide, thus more substance use/wrist cutting were revealed compared to more lethal methods (such as hanging or "other methods") identified in suicide registry studies in other nations like Australia [20]. Our finding of the prevalent methods of suicide attempts was similar to the Korea National Suicide Survey, which divided suicide attempts into low lethality (covered drug overdose or self-cutting behavior) and high lethality (covered by other methods) [21]. Further, the previous Korean study concluded that multiple factors affected selection of suicide method of high lethality, such as older age, male sex, no previous psychiatric history, previous suicide attempt, and high suicide intent. In consideration of the influences of nature and nurture toward suicide behaviors, the trajectories of suicide attempts and the path to completed suicide appeared to inform different suicide risk profiles and clinical treatment needs [22,23]. The method selection and its relating factors worth more investigations in the future to disentangle what should be included in suicide prevention strategies.

Unlike most studies of non-fatal self-injurious behavior in the literature, the current study derived from national dataset across 17 years rather than using cross-sectional data in just a (few) year(s). This study is advantageous of its sample size and longitudinal feature of a difficult-to-collect high-risk group of suicide due to national policy of suicide surveillance from the central government. However, the study mainly selected limited numbers of variables in the descriptive-based statistical analysis. While we reached the goal of presenting long-term trends across COVID-19 for before-and-after comparison, more related factors or reasons behind the epidemiological results found in this study require further investigations and understandings for specific preventive interventions or policy-making. The reasons of the contradict trend of increase on suicide attempt and decrease on suicide deaths in Taiwan during the pandemic period of COVID-19 were unknown and different from other studies [24, 25] that require longer term of observations.

Acknowledgments

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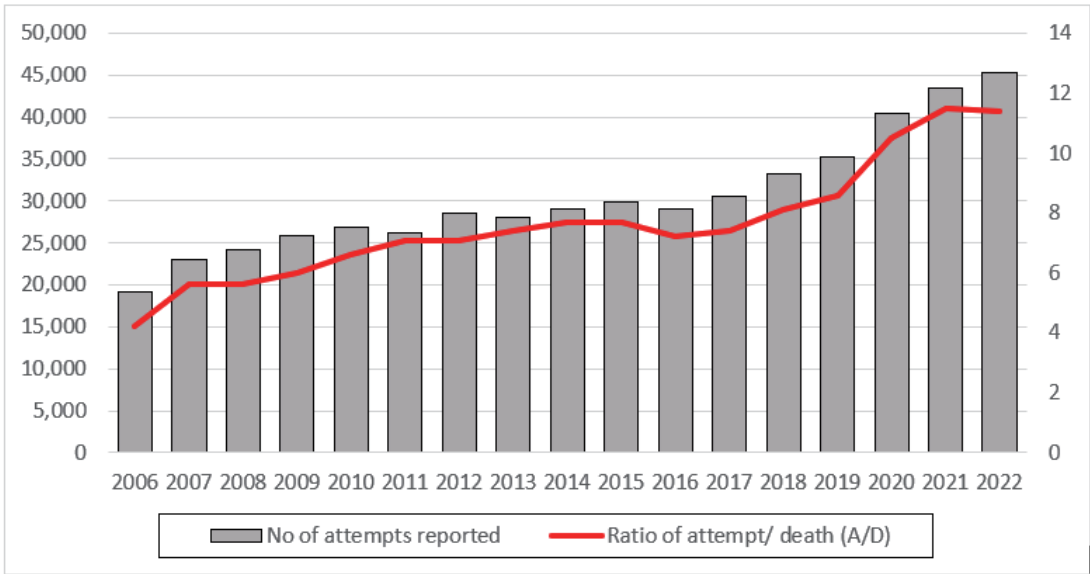
Appendix

Figure 1. Number of suicide attempt reports and ratio of attempt/ death (A/D) by year during 2006-2022.
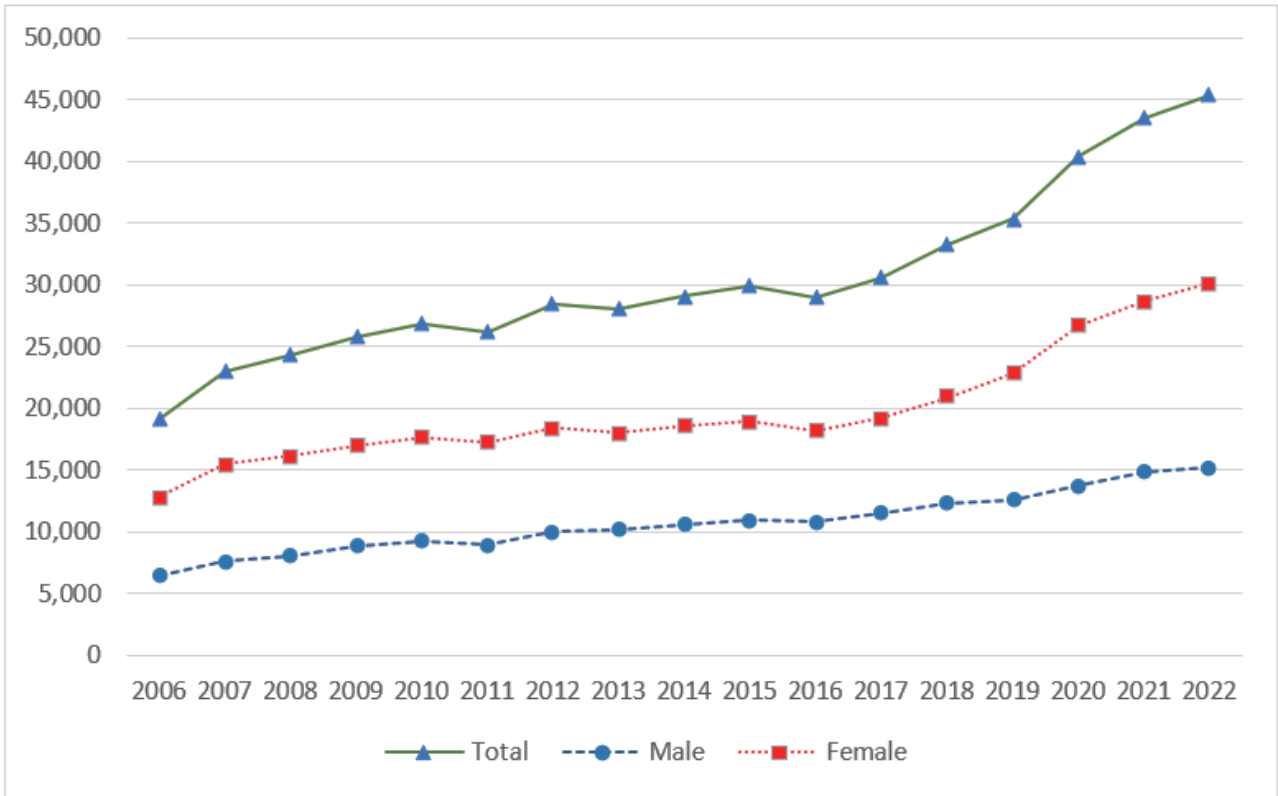

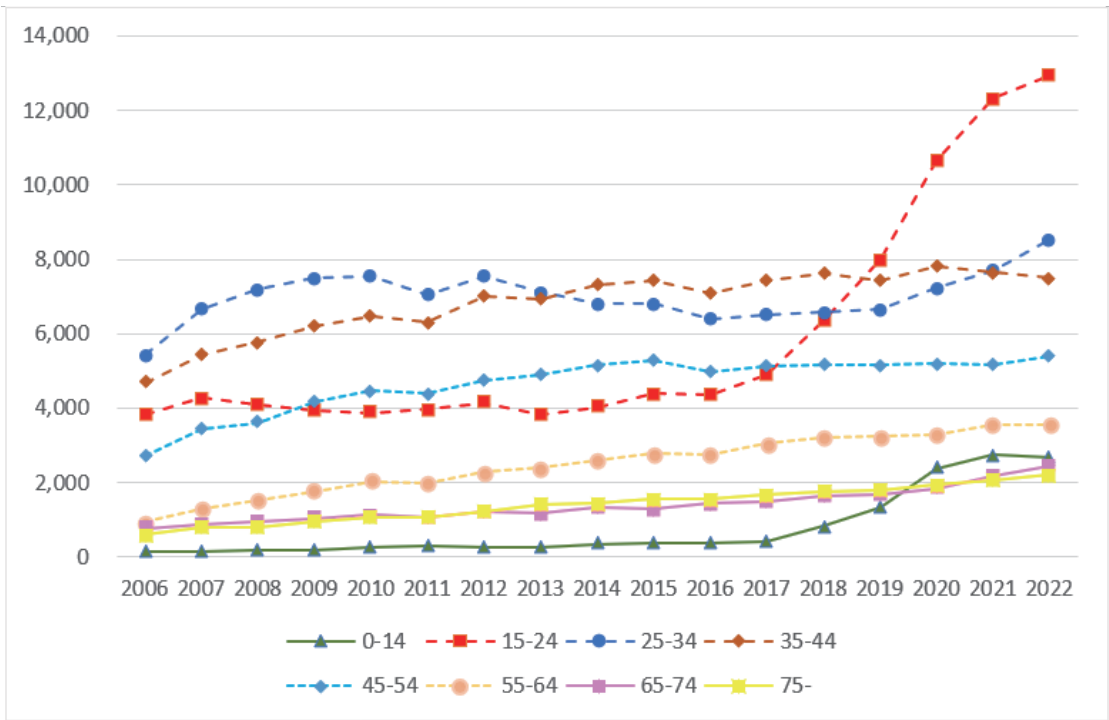**Figure 2.** Number of suicide attempt reports by gender during 2006-2022.

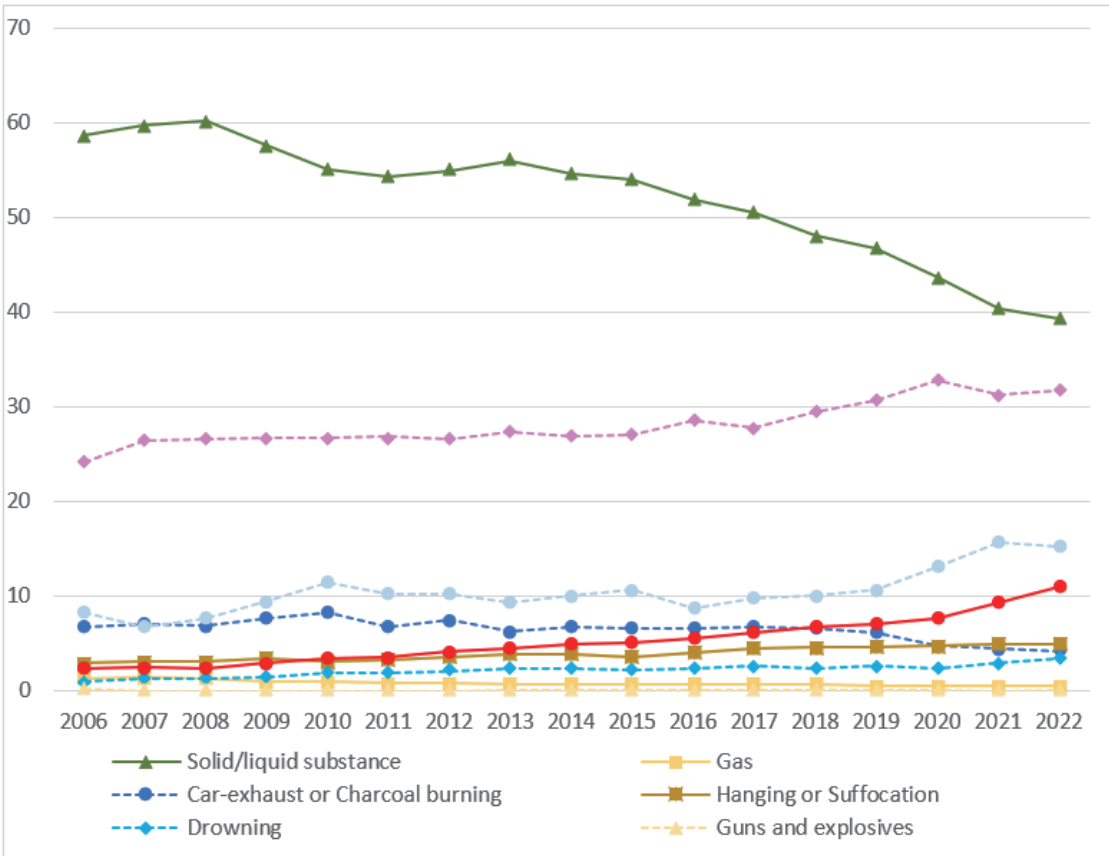**Figure 3.** Number of suicide attempt reports by year during 2006-2022.

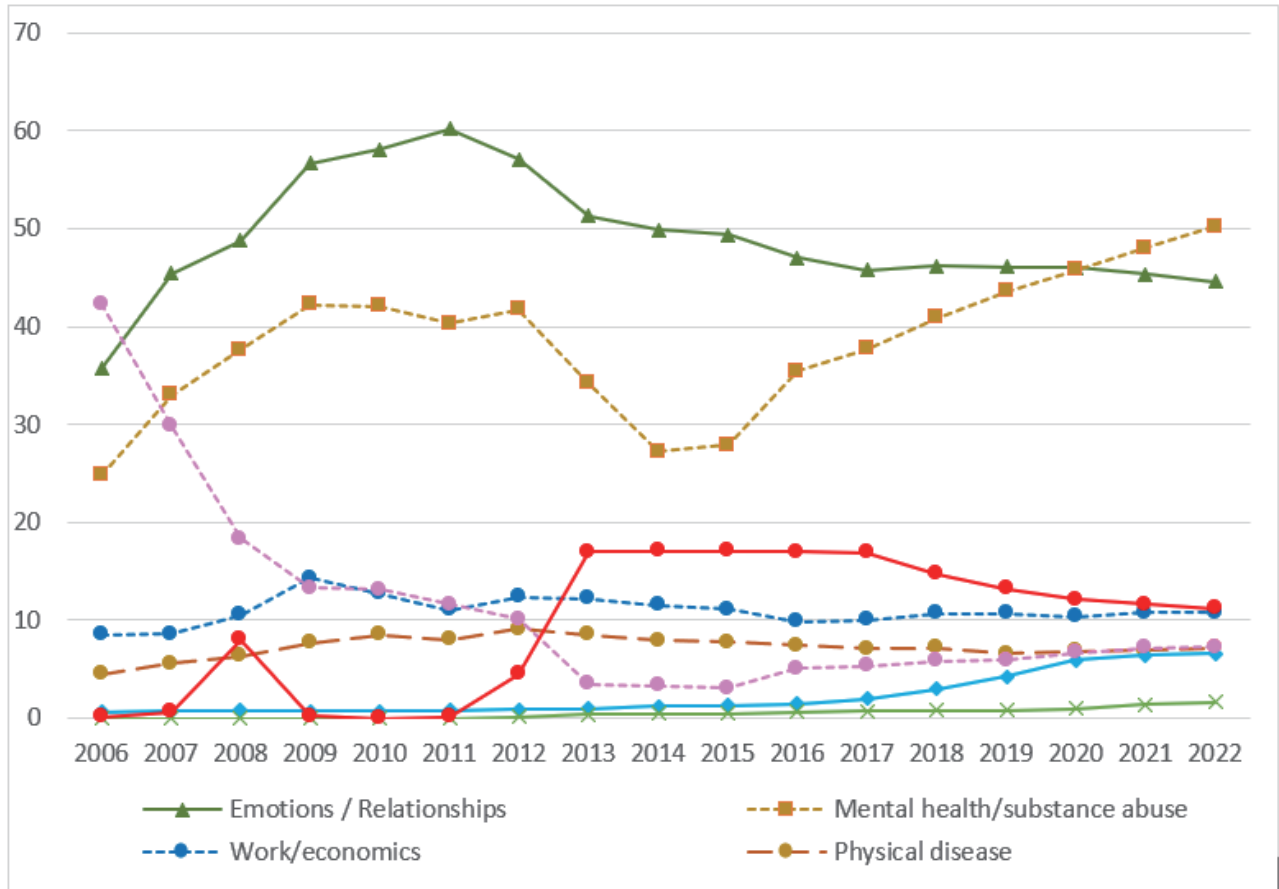**Figure 4.** Methods of suicide attempts (%) by year during 2006-2022.

Figure 5. Causes of suicide attempts (%) by year during 2006-2022.

A Nationwide Community Survey on COVID-19 Stressors, Psychological Distress and Suicidality in Taiwan

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Abstract: *Objective:* COVID-19 stressors and psychological stress responses are important correlates of suicide risks under the COVID-19 pandemic. This study aimed to explore the impact of COVID-19 stress on mental health and suicidality among the general population during the outbreak of COVID-19 in 2021 throughout Taiwan. *Methods:* A nationwide population-based survey was conducted by using a computer-assisted telephone interview system and a stratified, proportional randomization method. The questionnaire comprised demographics, psychological distress assessed by the five-item Brief Symptom Rating Scale, COVID-19 stressors, and suicidality. *Results:* In total, 2119 respondents completed the survey (female 50.8%). The most prevalent COVID-19 stressors were related to job/financial concerns and daily life stress. Higher levels of psychological distress had significantly higher odds of having COVID-19 stress. The structural equation modeling revealed that psychological distress was the mediator between COVID-19 stressors and suicidality. *Conclusions:* The findings call for attention to suicide prevention strategies of mental health promotion to prevent psychological consequences in situations similar to the COVID-19 pandemic.

Introduction

It has been recognized that the novel coronavirus (COVID-19) may result in severe mental problems since the outbreak in March 2020 [1] with a total of 25% to 50% of the global population experiencing psychological impacts during the pandemic [2,3]. The overall pooled prevalence of the psychological responses might range from 30 to 40% in different countries in a systematic review [2]. The COVID-19 outbreak led to restriction policies, blunted economic growth, increased rates of unemployment, financial insecurity, and poor mental health as well as suicide risks [4,5]. In a large-scale international longitudinal study conducted in 2020, participants' perceived economic burden was associated with worse mental health, as indicated by their reduced diet quality, sleep quality, and increased smoking [6]. Another large national study in the US also revealed that the COVID-19 pandemic harmed mental well-being through identified stressors (e.g., restricted social contacts, fear of infection, and concerns about economic hardship) [7]. Furthermore, economic recession has been noted to be associated with increased suicide risk in comparison with the period of prosperity [8, 9]. More recent surveys revealed that the peak psychological impact of COVID-19 might be delayed after the outbreak; therefore, follow-up for those who were jobless or bothered by financial embarrassment should be the key issue in suicide prevention [5, 10]. In a nationwide

population-based survey conducted in Taiwan in 2020, 45.4% of the participants experienced COVID-19-related stress [11]. The most prevalent stressors of the participants were related to daily life and job/financial concerns. In the meanwhile, participants with more suicidality, loneliness, and less self-efficacy were more likely to have COVID-19 stress. In this study, we aimed to explore the associations between COVID-19 stressors, psychological distress, and suicidality using data from the nationwide population-based survey one year after the study in 2020. The concept of COVID-19 stressors refers to five domains of stressors over the past month during the COVID-19 pandemic, including physical health, mental health, family/interpersonal relationships, work/financial, daily life, and academic problems.

Methods

Study setting and data collection

The study used a computer-aided telephone interview method to recruit a representative sample of Taiwan in 2021. In this survey, the landline telephone numbers were randomly selected through stratified proportional sampling based on the distribution of population size, gender, and age in various geographic regions of Taiwan. The study was approved by the Institutional Review Board at National Taiwan University Hospital. Respondents and/or their legal guardians provided informed consent and were notified of the

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anonymity and confidentiality of the study. All data were collected by trained telephone interviewers.

Participants

All participants were aged ≥ 15 years old and agreed to attend the survey over the phone and complete the interview. The method and procedure of participant recruitment were described elsewhere [12]. The sampling procedure was performed by the project administrator of the Taiwan Suicide Prevention Centre. Participants were contacted upon sampling by telephone survey on psychological distress, COVID-19 stressors, and suicide ideation. Oral consent was obtained from participants prior to the telephone interviews in accordance with the ethical approval of the National Taiwan University Hospital Institutional Review Board (No. 201204034RIC).

Measurements

Psychological distress

The five-item Brief Symptom Rating Scale (BSRS-5) was used to measure the level of psychological distress during the past week [13, 14]. It is a 5-point Likert scale (0–4) including five questions: (1) having trouble falling asleep (insomnia); (2) feeling tense or keyed up (anxiety); (3) feeling easily annoyed or irritated (hostility); (4) feeling low in mood (depression), and (5) feeling inferior to others (inferiority). An additional question for assessment of recent suicide ideation ("Do you have any suicide ideation in the past week?") was added at the end of the scale. The BSRS-5 has satisfactory psychometric properties to detect psychiatric morbidity and recent suicide ideation in clinical settings and the community [15,16]. The cut-off points for the presence of psychiatric morbidity were BSRS-5 scores 5/6. The internal consistency of the BSRS-5 in this study was satisfactory (Cronbach's alpha: 0.74) and comparable with the previous study (0.80) [11].

COVID-19 stressors

All the participants were asked whether they experienced any of the following six domains of stressors over the past month during the COVID-19 pandemic, including physical health, mental health, family/ interpersonal relationships, work/financial, daily life, and academic problems. These domains were designed to reflect the sources of stress during the COVID-19 pandemic. The response options were "Yes" (1 point) or "No" (0 point). The response of "Yes" in each domain of COVID-19 stressors stood for the presence of COVID-19 stress.

Suicide ideation

We evaluated whether the respondents had suicide ideation in the past week. The above items were screening questions drawing responses of "Yes" or "No".

Statistical analysis

Data were analyzed after weighting for age and gender by the raking weighting method to make the sample best represent the general population of Taiwan. In addition to descriptive statistics of demographic variables, the chi-square test was applied to examine the differences in COVID-19 stress by sex. Moreover, the stepwise regression was applied to predict the psychological distress and suicide ideation caused by the COVID-19 stressors, respectively. At last, path analysis was used to present the relationships between COVID-19 stressors, psychological distress, and suicide ideation.

Results

Participant characteristics

A total of 2119 participants were recruited nationwide for this study inclduing 1042 (49.2%) males and 1077 (50.8%) females (Table 1). The most common COVID-19 stressor was stress related to job/financial trouble (30.9%, n=659) and stress related to daily life (29.9%, n=639), followed by mental health conditions (16.7%, n=351), family/interpersonal relations (13.5%, n=285), and physical health conditions (13.0%, n=275). Among all 221 students in this study, 22.6% of them (n=50) were stressed by academic problems.

Demographics and COVID-19 stressors

There were significant sex differences in the two domains of COVID-19 stressors. Female participants were likely to have mental health stress than male participants (p=0.017); male participants tended to have more daily life stress than female participants (p=0.002).

Psychological distress, suicide ideation, and COVID-19 stressors

Table 2 illustrates the independent associations between psychological distress, suicide ideation, and the presence of COVID-19 stress. All five COVID-19 stressors appeared significantly correlated with the BSRS-5 total scores. On the other hand, only three COVID-19 stressors (i.e., stress related to daily life, physical health conditions, and stress from job/financial difficulties) significantly predicted suicide ideation in the past week. The pattern for the relationships between the COVID-19 stressors, psychological distress, and suicide ideation is shown in Figure 1. The result of structural equation modeling implied that all COVID-19 stressors except for stress related to daily life significantly predicted the BSRS-5 total score, and the higher score of psychological distress further significantly impacted participants with more severe suicide ideation.

Table 1. Weighted prevalence of COVID-19 stressors by sex.

	Male N=1042 n (%)	Female N=1077 n (%)	Total N=2119 n (%)	χ^2	p
Physical health				7.688	0.104
0	916 (87.9)	928 (86.2)	1844 (87)		
1	70 (6.7)	95 (8.8)	165 (7.8)		
2	31 (3)	39 (3.6)	70 (3.3)		
3	14 (1.3)	6 (0.6)	20 (0.9)		
4	8 (0.8)	6 (0.6)	14 (0.7)		
Mental health				12	0.017
0	885 (85.2)	873 (81.4)	1758 (83.3)		
1	99 (9.5)	149 (13.9)	248 (11.7)		
2	30 (2.9)	34 (3.2)	64 (3)		
3	17 (1.6)	10 (0.9)	27 (1.3)		
4	8 (0.8)	6 (0.6)	14 (0.7)		
Stress of family/interpersonal				4.31	0.366
0	899 (86.4)	929 (86.6)	1828 (86.5)		
1	79 (7.6)	91 (8.5)	170 (8)		
2	41 (3.9)	37 (3.4)	78 (3.7)		
3	17 (1.6)	9 (0.8)	26 (1.2)		
4	4 (0.4)	7 (0.7)	11 (0.5)		
Stress of job/financial trouble				8.32	0.081
0	707 (68)	753 (70)	1460 (69.1)		
1	152 (14.6)	167 (15.5)	319 (15.1)		
2	87 (8.4)	91 (8.5)	178 (8.4)		
3	42 (4)	35 (3.3)	77 (3.6)		
4	51 (4.9)	29 (2.7)	80 (3.8)		
Stress related to daily life				17.348	0.002
0	722 (69.8)	758 (70.4)	1480 (70.1)		
1	165 (15.9)	193 (17.9)	358 (17)		
2	84 (8.1)	90 (8.4)	174 (8.2)		
3	28 (2.7)	25 (2.3)	53 (2.5)		
4	36 (3.5)	10 (0.9)	46 (2.2)		
Stress of academic problems*	N=116	N=105	N=221	5.389	0.250
0	89 (76.7)	82 (78.1)	171 (77.4)		
1	17 (14.7)	16 (15.2)	33 (14.9)		
2	8 (6.9)	3 (2.9)	11 (5.0)		
3	2 (1.7)	1 (1.0)	3 (1.4)		
4	0 (0)	3 (2.9)	3 (1.4)		

Note: *Only students were included for the analysis.

Table 2. Stepwise regression on psychopathology and suicidal ideation by COVID-19 stressors.

	β	Adjusted R^2	p
BSRS-5 total			
Mental health	0.946	0.215	<0.001
Stress related to daily life	0.319	0.257	<0.001
Stress of family/interpersonal issues	0.594	0.281	<0.001
Stress of job/financial troubles	0.313	0.295	<0.001
Physical health	0.476	0.304	<0.001
Suicide ideation			
Stress related to daily life	0.017	0.023	<0.001
Physical health	0.021	0.028	0.002
Stress of job/financial troubles	0.011	0.031	0.005
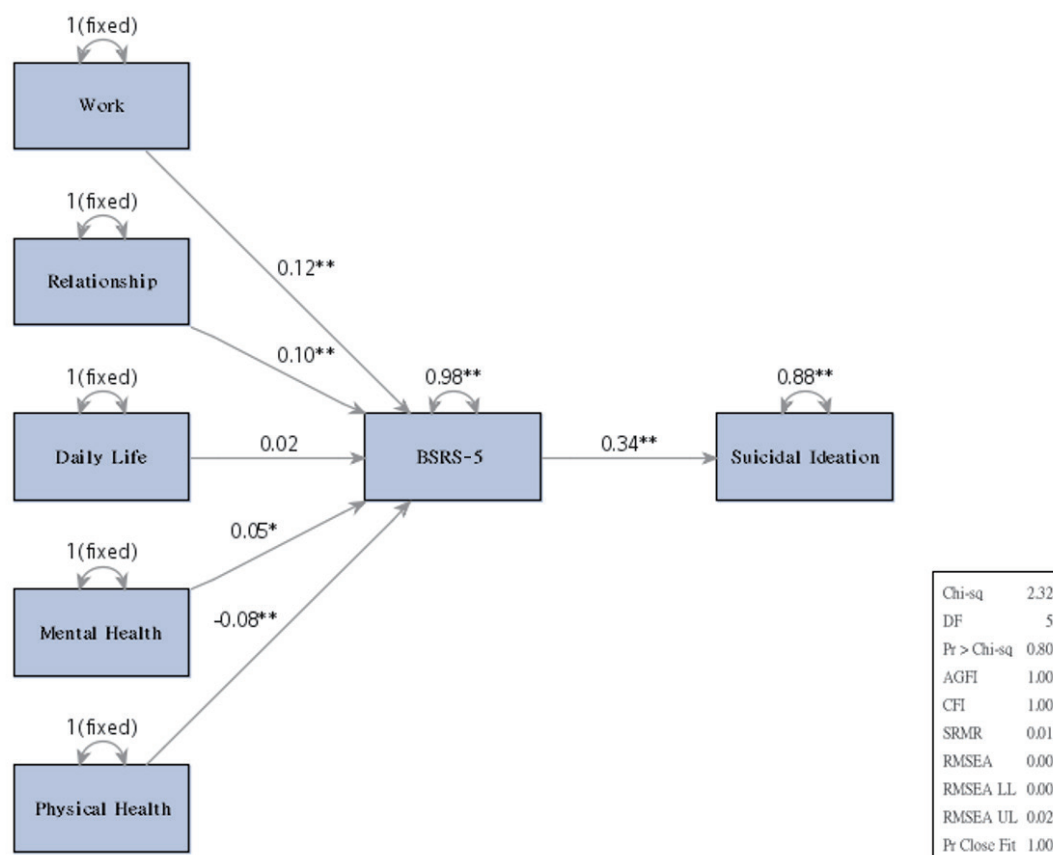
Figure 1. Path analysis on suicide ideation by BSRS-5 scores and COVID-19 stressors using structural equation model (the values on the lines represent standardized regression coefficients). The model fit statistics were as follows: Cmin/Df = 0.464 < 3, CFI = 1 > 0.9, AGFI = 1 > 0.9, RMSEA = 0.00 < 0.05).

Discussion

This population-based survey investigated COVID-19 pandemic stressors with the correlates of psychological distress and suicide ideation during the outbreak in 2021. Two common COVID-19 stressor was stress related to job/financial trouble and stress related to daily life. Psychological distress played a mediating role in the resulting suicide ideation from the COVID-19 stressors. These findings add to the literature that supports a relationship between the impact of COVID-19 stressors on psychological distress and suicide risk in the Taiwanese general population.

The COVID-19 pandemic has posed significant challenges to the public and individuals in many aspects of life, such as socializing, working, studying, living, and lifestyle [17]. This disruption of daily routines and rhythm may greatly impact mental health during the crises [17,18]. Taiwan, like other countries, faced a massive reduction in economic activities as the COVID-19 pandemic lingered. Many industries especially tourism and food sectors were among the worst-hit services in Taiwan and negatively impacted the whole society [19]. As a result, more people experienced salary cuts and unemployment throughout the pandemic. As for the suicide risk, our finding is consistent with global literature suggesting that the uncertainty of financial impact and the unemployment rate can put individuals at greater risk for developing psychological distress and suicidality during the pandemic [20]. What is more, the mediating role of psychological distress found in this study may serve as the basis of suicide prevention. Further research is needed on effective strategies for alleviating psychological distress.

Acknowledgment

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A 15-Year-Old Male with Attention Deficit Hyperactivity Disorder (ADHD) and Recent Suicide Attempt

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Abstract: *Background:* Suicide is a global concern, and attention deficit hyperactivity disorder (ADHD) patients without proper treatment often suffer from suicide events, in addition to various adversities and comorbidities. Untreated ADHD patients who attempt suicide may first encounter medical and surgical intervention and then rely on psychiatric consultation and referral for further psychiatric evaluation and management. *Clinical Case:* A 15-year-old male presented to our Emergency Department (ED) after a suicide attempt by jumping from the 6th floor, leading to a pelvic fracture. He was promptly admitted to our orthopedic service for open reduction of a pelvic fracture. Although he denied any pervasive depressed mood prior to the suicide attempt, he was in a state of loss of cognitive control, affective disturbances, entrapment, and hyperarousal, which was compatible with Suicide Crisis Syndrome. His suicide may be best formulated as suicide narrative (humiliation, social defeat, and perceived burdensomeness), precipitated by stressful life event, and aggravated by poor coping mechanism and impulsivity from ADHD (which he was diagnosed 3 years earlier, though he never adhered to regular treatment). A timely Consultation-Liaison (C-L) psychiatric consultation was ordered, after he was medically and surgically clear. A psychiatrist visited, evaluated his mental condition, provided supportive psychotherapy, and discussed the treatment options of ADHD. He was referred back to the psychiatric local medical department (LMD), treated regularly with Atomoxetine, and showed a stable improvement in his ADHD symptoms and denied further suicidal ideation. *Conclusions:* This case highlights the risk associated with ADHD, and untreated ADHD. In addition, the role of C-L Psychiatry in the management of suicide risk and formulation of suicide risk using the narrative-crisis model is also discussed.

Keywords: ADHD, suicidality, consultation-liaison psychiatry, suicide crisis syndrome, Abbreviated Suicide Narrative Inventory (A-SNI), Suicide Crisis Scale (SCS-5), BSRS-5, suicide prevention.

Introduction

Suicide identification and prevention is an essential part of every psychiatrist's work. However, over two-thirds of individuals who die from suicide did not seek professional mental health support in the one year prior to suicide attempt [1]. Effective suicide preventions rely on timely referral not only from the Emergency Department (ED), but also from the medical ward, which are largely done in the form of a Consultation-Liaison (C-L) Psychiatry consultation.

Here, we present a case of an adolescent with undertreated ADHD who attempted suicide and was admitted to the orthopedic ward, highlighting the role of C-L psychiatry in suicide identification and prevention, and discuss the patient's suicide risk using the Narrative-Crisis Model of suicide.

Case Report

Mr.C was a 15-year-old teenager, who was brought to our Emergency Room on Sep 3rd, 2022, due to pelvic internal bleeding after he jumped from the 6th floor of the building where he lived with his family. At the ED, his pelvic fracture with internal bleeding was impressed, and he was admitted to the orthopedic ward for surgical intervention.

After his surgery and after his condition had grossly stabilized, the orthopedic service consulted the consultation-liaison (C-L) psychiatrist to evaluate his mental condition and further suicide risk.

During his psychiatric interview, the following information was disclosed:

Mr. C was born the second child in the family, with an elder brother 3 years older than him. He was born full term with no adversities during birth. He began to talk and walk about the same time when he was just over 1 year old. There was no developmental delay noticed during the first few years. However, inattention and hyperactivity had been noticed since kindergarten, along with poor sustained attention, easy distractedness, forgetfulness, absent mindedness, intrusive speech, and being out of seat constantly during class. As he grew up, the above condition persisted into his elementary school years and even worsened: he was impatient

waiting, and his academic performance was constantly below average. Although described by his father to be somewhat stubborn when growing up, he showed no signs of significant social impairment, or restricted and repetitive behavior or interest. He had his fair share of support from his friends, and he described his social life as satisfactory.

At the suggestion of his teacher, he was first brought to our psychiatric service by grade 6. Given the above symptoms, he was soon diagnosed with ADHD, and a treatment program began immediately with Ritalin 10mg 1# qd prescribed. Unfortunately, after a few appointments, his follow up visits were discontinued because of his intolerance of the medication's side-effects, which included abdominal discomfort and sleep disturbance.

During his junior high school years, he still felt upset due to his poor academic performance, but he did not have any difficulty making friends in school nor did he suffer from frustration due to parent-child relationship difficulty at home. As Mr. Cheng recalled, he constantly felt depressed about his academic performance; and from time to time, he would have ideation of death. He would also intermittently have arguments with his teacher, and impulsively threatened to jump off from a building. But he never had an elaborate suicidal plan, nor suicide attempt.

A few months prior to his ER admission, he graduated from junior high school and enrolled in the department of computer science in a vocational high school as he had wished for and was highly interested in. However, things did not go well: days after school started, he once again struggled with the heavy academic course load , despite his hard work and strong aspiration. He felt stressed and lonely. One day, he even accidentally fell asleep during a class, making him feel extremely guilty, depressed, and frustrated.

On September 9th, he went to the top of the building where he lived (while his father was sleeping at home) and jumped off from the building, leading toa pelvic fracture. Hearing the loud noise of his falling down, his neighbor found him and called 911. Subsequently, he was sent to the ER.

As objectively observed by his father, there were no abnormalities noted in his condition prior to this event: he showed no signs of significant sleep disturbance, appetite change, or psychomotor retardation.

He denied having ever done cigarette smoking, alcohol drinking, or any other illicit substance use.

During hospitalization, Mr. C's mood was less depressed and grossly stable.

A psychiatrist and a psychologist paid him regular visits to evaluate his mental status and gave him warm support during his hospitalization. During their visits, a discussion regarding future treatment options of ADHD was carried out.

After his hospitalization and his condition stabilized, he was discharged on September 19th. He was followed up at our Psychiatric outpatient clinic and was administered Atomoxetine   25mg daily in the first 7 days. He tolerated the medication Atomoxetine 40mg per day well since significant medication side effects were not noticed. In addition to inpatient care, we also provided follow-up phone-calls from the psychologist department, which all indicated stable improvement.

Discussion

Suicide is a complex global health issue, with >1% of death resulting from suicide, according to the World Health Organization. In terms of total mortality from suicide, more than 700,000 people are estimated to die from suicide every year. Suicide is especially concerning when we are faced with pre-existing primary psychiatric disorders, such as ADHD, as illustrated in this case.

In the following discussion, we will discuss the suicidal risk posed by ADHD, the importance of consultation-liaison psychiatry in suicide prevention, recent development in the model of suicide, and associated tools to identify suicide risk.

ADHD and suicide risk

The relationship between ADHD and increased suicide risk has been well-documented in the literature review. A 2017 review showed a positive association between ADHD and suicidality in both sexes and across all ages [2]. A 2020 review further revealed that suicide risk in ADHD individuals may be mediated by increased comorbid conditions, such as depressive disorders and substance use disorders [3].

Since ADHD persons possibly belong to a homogeneous group and can be further separated into inattentive subtype, hyperactive-impulsive subtype, and combined subtype, it is also of clinical interest as to how the different subtype may differ in terms of suicide risk. According to one prospective study in 2010, greater risk is associated with ADHD of combined subtype, (compared to inattentive subtype or hyperactive-impulsive subtype), indicating that both inattention and hyperactive-impulsive psychopathology may be involved in the development of suicide risk [4].

The timely identification of ADHD and subsequent adequate treatment may lower suicide risk. As revealed in a 2020 study, stimulant medication was associated with a reduced risk of suicide attempts in patients with ADHD, while nonstimulant medication is unlikely to increase the risk of suicide attempts [5].

Consultation-Liaison psychiatry and suicide prevention

Consultation-Liaison (C-L) psychiatry is a subspecialty of psychiatry that is of particular importance, especially in general hospital settings. C-L psychiatry recognizes and treats mental illnesses in nonpsychiatric inpatients, helps provide collaborative care in the mind-body interface, and serves as first-line care providers in identifying those in need of psychiatric attention, among those with a chief problem of physical illnesses.

A proportion of people with suicide attempt who present to ED were admitted to the non-psychiatric ward, mostly those whose attempt results in physical damage. Some examples include: patients with carbon monoxide poisoning, if severe enough, would often be admitted to the pulmonology ward for hyperbaric oxygen therapy; patients who jump off from a building resulting in fracture, trauma, or intracranial hemorrhage would often

be admitted to the orthopedic ward or trauma ward for surgical intervention and intensive care; and patients with medication overdose who had acute renal failure or toxic hepatitis would be admitted to the internal ward for medical monitoring and treatment.

It is worth noting that not all suicidal patients presenting in the C-L psychiatry setting are patients post suicidal attempt. Patients with delirium and substance withdrawal may also be at high risk for self-harm due to agitation and impulsivity. Patients with chronic, painful, or terminal conditions may also experience unbearable suffering and flag hope. (In an Italian multi-center study, over 20% of medically ill patients were at suicide risk, and over half of these patients were at high suicide risk[6]). In these demographics, medically ill patients may not reveal an actual wish to be dead, but instead only express a passive wish to "give up" or an active desire to harm themselves. By collaborating with C-L psychiatry, a C-L psychiatrist may discern the issues underpinning a patient's wish or desire, identify suicide risks, provide appropriate care, and foster hope and offer relief.

Medical treatment and stabilization of physical condition are urgent and important. However, further suicide prevention and collaborative bio-psycho-social care integration rely on multi-disciplinary care, which often starts in referral to consultation-liaison psychiatry, and as we currently know, were not mandated in many places, and are initiated only when the primary care physician is aware of the importance. In a study conducted in India, only a little more than half of the suspected suicide attempters (51.4%) were referred for psychiatric review [7], highlighting the importance of sensitizing the referring doctors on the importance of the psychiatric referral.

Suicide risk, while relatively rare in children, increases significantly in prevalence throughout adolescence. In a population-based study in Taiwan, more than 11% of 15 to 19-year-old adolescents reported ever having suicidal ideation in their lifetime [8].

Furthermore, according to Taiwan Society of Suicidology (TSOS), suicide among patients ranging from age 15-24 has increased more than 70% in the past 10 years. Thus, the importance of timely detection of suicidal ideation, and psychiatric referral, applies not only to the medical and surgical ward, as mentioned above, but also to the pediatric department as well.

Recent model of suicide and tools to identify suicide risk

There are numerous tools of suicide risk evaluation that are commonly used in the clinical setting. The SAD PERSONS scale, for example, focuses mainly on static epidemiologic factors, such as gender, age, marital status, previous attempt, and presence of psychiatric illness [9]. Another widely used scale is the Beck Scale for Suicide Ideation (BSI), developed by Aron T. Beck, which puts emphasis on more dynamic factors measured post-suicide attempt, such as the objective circumstances related to suicide attempt, one's purpose, expectations, seriousness of an attempt, and one's reactions to it.

While both are valid and well-studied evaluation tools, neither alone is complete, considering the complex nature of all factors that together lead to suicide attempt. While imminent suicide may be precipitated by crisis, suicide ideation and subacute risk precede long before and may not be fully captured by either static factors (as presented by the SAD PERSONS scale) or dynamic factors measured post-attempt (as presented by the BSI). In the following text, we present a new model to formulate the development of suicide and suicide risk.

The narrative-crisis model of suicide

The Narrative-Crisis Model is a novel, stepwise model, which describes a sequence in which people with trait vulnerability (chronic risk factors), triggered by an acute stressful life event, develop a subacute state termed the suicide narrative, which can further precipitate an acute negative affect state termed the suicide crisis syndrome (SCS), which in turn can lead to increased imminent suicidal risk.

Trait vulnerability

Trait vulnerability component of NCM consists of chronic and relative static risk factors distal to suicidal behavior. Examples include impulsivity, substance abuse, insecure attachment, poor social support, and childhood trauma [10–13].

Suicide narrative

The suicidal narrative focuses on psychological distress related to the life narrative of a suicidal individual. Six constructs included are: thwarted belongingness, perceived burdensomeness, humiliation, social defeat, goal disengagement, and goal re-engagement; with the first four grouping into "interpersonal factors", and the last two grouping into "goal orientation factors". The Suicide Narrative Inventory (SNI) was a 102-question (5-point Likert scale) developed to measure suicide narrative. Its validity among community residents in Taiwan were examined and has shown good psychometric properties [14].

Suicide Crisis Syndrome (SCS)

Suicide crisis syndrome describes a hyperaroused negative affect state preceding suicidal behavior (SB). The original SCS formulation included five dimensions: entrapment, panic dissociation, emotional pain, fear of dying, and ruminative flooding, and could be assessed using Suicide Crisis Inventory (SCI), which is a 49-item self-report rating scale. The formulation was later revised to include five dimensions: entrapment, affective disturbance, loss of cognitive control, hyperarousal, and social withdrawal, and could be assessed using the Five-Item Suicide Crisis Scale (SCS-5), which showed excellent internal consistency and good correlations with all items of the BSRS-5, SNI and suicidality measures [15].
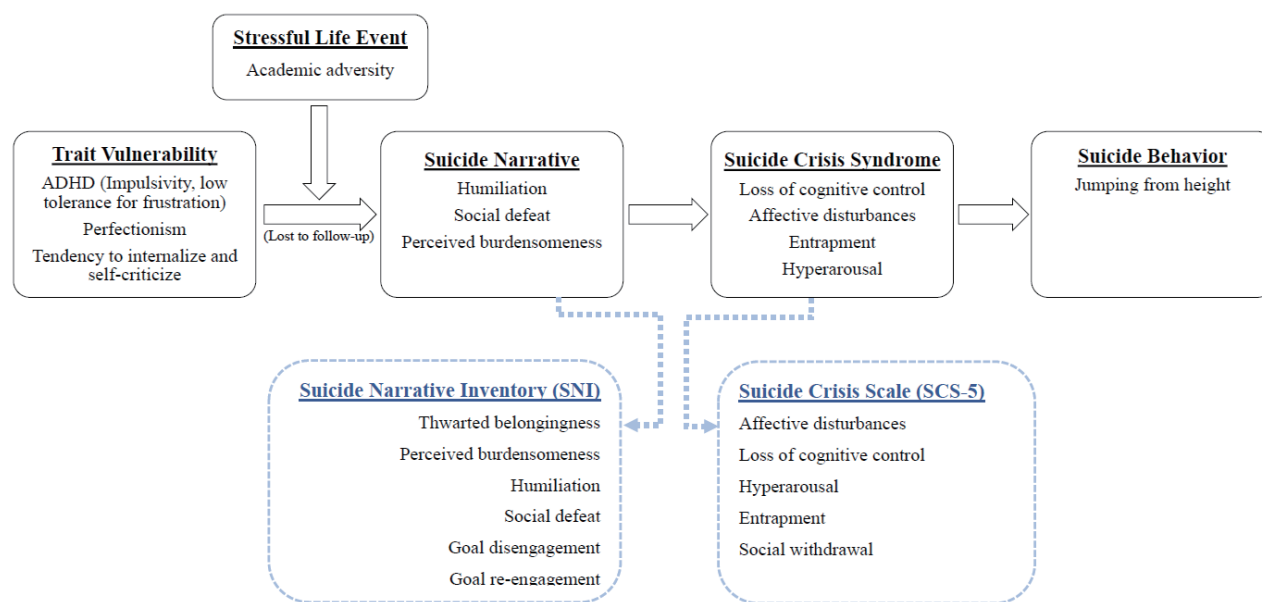
Figure 1. Bio-psycho-social formulation of suicide process by integrated components of predisposition, precipitation, perpetuation and protection.

Additional advantages of SNI and SCS-5

In addition to collectively forming a cohesive time and sequence-informed model of the development of suicidal ideation and suicide attempt, SNI and SCS-5 have an additional methodological advantage of having the "empathic" mindset built into its construct.

For example, nearly all items of SNI focus on one's "feelings" (e.g., I feel down and out, I feel powerless, I feel I am in a deep hole I cannot get out of). The SCS-5 further extends the focus from a more psychological feeling to a visceral and affective feeling, (e.g., feeling unusual physical sensations, feeling that head could explode from having too many thoughts, feeling that ordinary things looked strange or distorted, feeling that the world was closing in).

Note that none of the questions of SNI and SCS-5 try to directly inquire about "suicide"; but rather, they focus on one's "narrative", and all of the epiphenomenon (or the precursor, depending on how one sees it) of suicidal ideation.

This has a clear advantage in a clinical setting, considering that suicidal persons often conceal their suicidal ideation and plan, to avoid being blamed or being intervened (which is to say, relying on explicit endorsement of suicidal ideation will likely lead to type II error, which is more detrimental in suicide prevention than type I error).

Back to the patient

This patient has traits of ADHD, including impulsivity, low tolerance for frustration; and personality that are prone to self-blame. All of these attributes were likely to have contributed to his long-term risk and trait vulnerability.

When he entered vocational high school, he had high hopes of his academic achievement, since it was the first time in his life that he could spend the majority of his school time on his academic interest, namely computer science. However, what awaited him was another setback, which triggered his suicide narrative, including humiliation, social defeat, and perceived burdensomeness (he thought about financial independence, and the thought of not achieving academics properly, put him in a position where he was afraid of not being able to support himself financially in the future, and making him ultimately rely on his parents), which, with his impulse control and lack of mature coping mechanism, further precipitated into his suicide crisis, and his eventual suicide attempt.

During retrospective recollection, the patient scored 92 points on the SNI, which was only slightly lower than the cutoff point, which is 99 points. On the SCS-5, the patient scored 10 points, which was significantly higher than the cutoff point, which is 5 points. On follow-up visits, both scores dropped well below the cut-off points, as did his BSRS-5 score.

The patient is now stable with inpatient follow-up visits and is planning on restarting school soon.

This case illustrates the importance of C-L psychiatry consultation in the identification, management, and prevention of suicide risk. Consultation allowed Mr. C to continue discussion about future psychiatric care, mainly ADHD symptoms management, which he discontinued due to previous medication side effects. Psychological and social aspect will also be explored further in the outpatient setting, which together with pharmacological treatment, formed the bio-psycho-social psychiatric care.

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1. **The *Journal of Suicidology* (JOS)** is the peer-reviewed open-access publication of the Taiwanese Society of Suicidology. The JOS welcomes the submission of articles from multidisciplinary fields of suicidology. The manuscripts must be original and must not have been previously published in or currently submitted for publication to any other journal.

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      2) Lee MB, Liao SC, Lee YJ, et al : Development and verification of validity and reliability of a short screening instrument to identify psychiatric morbidity. J Formos Med Assoc 2003;102(10):687-694.

   B. *Books*: author, title of chapter, editor, title of book, edition, place of publication, publisher, year, pages.

      1) Parsons AH, Parsons PH: Health Care Ethics. Toronto: Wall & Emerson, Inc., 1992;24-4.

      2) Esposito-Smythers C, Perloe A, Machell K, et al : Suicidal and nonsuicidal self-harm behaviors and substance use disorders. In: Kaminer Y, ed. Youth Substance Abuse and Co-occuring Disorders, 1st ed. Arlington: American Psychiatric Association Publishing,2016;227-252.

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