

Digital Stress, Perfectionism, and Suicide: Biological, Psychological, and Genetic Perspectives

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ABSTRACT

The accelerating digitization of daily life has introduced novel and pervasive psychological stressors with meaningful consequences for mental health. This paper provides a comprehensive theoretical and empirical review of the intersections among digital stress, perfectionism, and suicidal behavior, examined through biological, psychological, and genetic frameworks. Digital stress, arising from continuous connectivity, information overload, and the imperatives of curated online self-presentation, has emerged as a clinically significant risk factor, particularly among adolescents and young adults. Perfectionism, a multidimensional personality construct encompassing self-oriented, other-oriented, and socially prescribed dimensions, is increasingly reinforced by digital environments that valorize flawless performance and appearance. The convergence of these two constructs creates compounding pathways to suicidal ideation, planning, and behavior. Neurobiologically, chronic digital stress dysregulates the hypothalamic-pituitary-adrenal (HPA) axis, suppresses brain-derived neurotrophic factor (BDNF) expression, and promotes neuroinflammatory processes implicated in suicidality. Psychologically, maladaptive perfectionism intensifies cognitive vulnerabilities including negative self-evaluation, emotional dysregulation, and thwarted belonging. Genetically, polygenic risk scores for suicidal behavior interact with environmentally mediated epigenetic modifications, including those triggered by sustained digital stressors. This review integrates emerging evidence to propose a tripartite biopsychosocial model linking digital stress and perfectionism to suicide risk, and discusses implications for prevention, clinical intervention, and public health policy. The paper concludes with a call for transdisciplinary research that bridges genomics, computational psychiatry, and digital epidemiology.

Keywords: digital stress, perfectionism, suicide risk, HPA axis, BDNF, biopsychosocial model, social media, maladaptive perfectionism, epigenetics, mental health

INTRODUCTION

The twenty-first century has witnessed a transformation in human social experience so profound that its psychological consequences are only beginning to be adequately mapped. The proliferation of networked digital devices, the normalization of continuous online connectivity, and the emergent culture of curated self-presentation have generated a new class of psychological stressors collectively designated as digital stress. At the same time, perfectionism, long recognized as a significant psychological vulnerability, has been amplified by digital environments that broadcast idealized images of success, beauty, and productivity to billions of users simultaneously. The convergence of these phenomena has occurred against a backdrop of rising rates of suicidal ideation, attempts, and deaths, particularly among adolescents and young adults, prompting urgent scholarly attention to their possible interconnections.

Suicide remains among the most pressing public health challenges of our era. The World Health Organization estimates that approximately 700,000 people die by suicide annually worldwide, with many millions more experiencing suicidal ideation or making nonfatal attempts (WHO, 2021). Suicidal behavior is multiply

determined, arising from the interaction of biological vulnerabilities, psychological states, environmental stressors, and social factors. No single explanatory framework suffices, and this complexity has historically made both research and intervention difficult. Nevertheless, the past two decades have seen significant advances in identifying modifiable risk factors amenable to clinical and policy intervention, among which digital stress and perfectionism have emerged as increasingly important candidates.

The relationship between digital technology use and mental health has been the subject of considerable scientific and popular debate. Early research was marked by methodological inconsistencies, oversimplified dose-response assumptions, and a failure to distinguish between qualitatively different types of digital engagement (Orben & Przybylski, 2019). More recent work has moved beyond simple screen time metrics to examine the psychological mechanisms through which specific patterns of digital engagement generate distress. Digital stress is now understood as a multidimensional construct encompassing information overload, techno-invasion, techno-complexity, and the social comparison pressures endemic to social media platforms (Tarafdar et al., 2015). Each of these dimensions has been linked, through distinct pathways, to adverse mental health outcomes including depression, anxiety, and suicidal ideation.

Perfectionism has an equally complex and contested literature. Historically framed as either a unidimensional negative trait or a potentially adaptive motivational style, perfectionism is now most productively understood as a multidimensional construct with both adaptive and maladaptive variants (Frost et al., 1990; Hewitt & Flett, 1991). Maladaptive perfectionism, characterized by excessive self-criticism, fear of failure, and the perception that one's worth is contingent on flawless performance, has been reliably linked to depression, anxiety, eating disorders, and suicidality (Flett & Hewitt, 2014; Smith et al., 2018). Digital environments have introduced new domains in which perfectionistic standards are applied and new mechanisms through which socially prescribed perfectionism is transmitted and enforced.

The aim of this paper is to provide a rigorous and comprehensive synthesis of what is currently known about the relationships among digital stress, perfectionism, and suicidal behavior. We approach this synthesis from three complementary perspectives: the biological, encompassing neurobiological, neuroendocrine, and immunopsychiatric mechanisms; the psychological, focusing on cognitive, emotional, and behavioral pathways; and the genetic, examining heritability, polygenic risk, and gene-environment interactions. We then consider the methodological challenges confronting this field, the implications for evidence-based prevention and intervention, and the policy dimensions of this emerging public health concern. We conclude by proposing a tripartite biopsychosocial model that integrates insights from all three perspectives and identifies priority areas for future research.

This review is organized as follows. We begin with a critical examination of digital stress as a construct, reviewing its definitions, mechanisms, and prevalence data. We then turn to perfectionism, tracing its psychological foundations and its behavioral expressions in digital contexts. A review of suicide risk follows, situating it within the broader epidemiological and conceptual landscape. Subsequent sections examine each of the three analytical frameworks in turn before integrating them in a unified model. The final sections address methodological considerations, prevention and intervention strategies, and policy implications.

Digital Stress: Definitions, Mechanisms, and Prevalence

Digital stress, as a formal construct, emerged from the broader literature on technostress, a term introduced by Brod (1984) to describe the difficulty of adapting to new computer technologies. Subsequent decades witnessed the rapid expansion of what Brod's framework could encompass, as mobile computing, social media, ubiquitous connectivity, and algorithmic content curation transformed the nature and scale of human-technology interaction. Contemporary definitions of digital stress converge on several core elements: the perception of an imbalance between the demands generated by digital technologies and one's resources to cope with them; the experience of intrusion, distraction, and cognitive overload associated with continuous connectivity; and the social comparison pressures endemic to social media platforms (Tarafdar et al., 2015; Reinecke et al., 2017).

Empirically, digital stress is now recognized as a multidimensional construct. Tarafdar et al. (2015) identified five primary dimensions: techno-overload, referring to the state in which technology forces individuals to work faster and longer; techno-invasion, the experience of being reachable at all times and in all places; techno-complexity, the cognitive burden of learning and adapting to new systems; techno-insecurity, anxiety about losing one's position to more technologically competent peers; and techno-uncertainty, the distress generated by constant and unpredictable technological change. Each dimension generates distinct psychological pressures and activates different coping responses, though they frequently co-occur and interact in practice.

Prevalence data paint a concerning picture. By 2020, the global average time spent on digital devices had reached nearly seven hours per day, a figure approximately 20% higher than in 2019, with the COVID-19 pandemic accelerating this trend substantially (We Are Social, 2021). A large-scale survey conducted during the pandemic found that 42% of individuals aged 18 to 35 reported significantly increased digital stress during national lockdowns (Thomee, 2018). Among adolescents, rates of problematic social media use, a closely related construct, have been estimated at between 4% and 23% depending on the definitional criteria employed, with evidence suggesting that prevalence has increased over the past decade (Kuss & Griffiths, 2017).

The mechanisms linking digital technology use to psychological distress are multiple and partially overlapping. Social comparison theory, originally formulated by Festinger (1954), provides one important explanatory framework. Social media platforms afford users near-constant access to upward social comparisons, with algorithmically curated content disproportionately representing idealized presentations of appearance, success, and lifestyle. Meta-analytic evidence confirms that social media use is associated with increased social comparison activity and that these comparisons are associated with negative affect and decreased self-esteem (Vogel et al., 2014). For individuals with preexisting perfectionistic tendencies, these dynamics are likely to be particularly harmful, as they provide continuous evidence of the gap between actual and ideal performance.

Fear of missing out (FoMO), defined as the pervasive apprehension that others might be having rewarding experiences from which one is absent, represents another well-documented mechanism (Przybylski et al., 2013). FoMO motivates compulsive checking behaviors, disrupts sleep, and is associated with lower life satisfaction, higher anxiety, and depressive symptoms. Sleep disruption itself constitutes an important pathway from digital technology use to adverse mental health outcomes, with evidence suggesting that pre-sleep device use delays sleep onset, reduces total sleep time, and diminishes sleep quality, all of which are independently associated with depressive symptoms and suicidal ideation (Twenge et al., 2018).

Table 1 Dimensions of Digital Stress and Associated Psychological Mechanisms

Dimension	Definition	Primary Psychological Mechanism	Associated Outcomes
Techno-overload	Technology forces users to work faster and longer than desired	Cognitive load; attentional depletion	Burnout, fatigue, anxiety
Techno-invasion	Expectation of constant availability and reachability	Boundary violation; role spillover	Sleep disturbance, relationship conflict
Techno-complexity	Difficulty learning and using new systems	Self-efficacy erosion; helplessness	Technology anxiety, avoidance
Techno-insecurity	Fear of job loss to more tech-competent peers	Social threat appraisal; status anxiety	Occupational anxiety, depression
Techno-uncertainty	Distress from frequent, unpredictable technological change	Uncertainty intolerance	Chronic stress, rumination
Social comparison pressure	Continuous exposure to idealized peer representations	Upward social comparison; self-discrepancy	Low self-esteem, envy, suicidal ideation

Note. Adapted from Tarafdar et al. (2015) and Reinecke et al. (2017).

Perfectionism: Psychological Foundations and Behavioral Expressions

Perfectionism has been conceptualized in diverse ways across its intellectual history, but contemporary consensus regards it as a multidimensional personality construct whose central features include the setting of excessively high standards, a tendency toward harsh self-evaluation, and a preoccupation with mistakes and perceived failures (Frost et al., 1990). Hewitt and Flett (1991) contributed what remains one of the most influential frameworks, distinguishing among self-oriented perfectionism (demanding perfection of oneself), other-oriented perfectionism (demanding perfection of others), and socially prescribed perfectionism (believing that others demand perfection of oneself). Of these, socially prescribed perfectionism has consistently demonstrated the strongest and most robust association with psychopathology, particularly depression and suicidality (Flett & Hewitt, 2014).

The developmental origins of perfectionism involve a complex interplay of genetic predispositions and environmental experiences. Twin studies estimate the heritability of perfectionism at approximately 30% to 50%, suggesting that genetic factors contribute meaningfully but that environmental influences remain dominant (Tozzi et al., 2004). Parenting behaviors figure prominently in etiological accounts, with both overprotective and highly critical parenting styles associated with elevated perfectionism in offspring. Parental modeling of perfectionistic standards, contingent approval based on achievement, and explicit or implicit communication that mistakes are unacceptable have all been identified as formative environmental influences (Vieth & Trull, 1999). Cultural factors, including achievement-oriented societal values and the competitive structures of educational institutions, further shape the expression of perfectionistic tendencies across development.

The relationship between perfectionism and psychopathology is well established but not straightforward. Early conceptualizations tended to treat perfectionism as uniformly pathological, but subsequent research revealed meaningful distinctions between adaptive and maladaptive variants. Adaptive perfectionism, sometimes termed perfectionistic strivings, involves the pursuit of high standards in a context of psychological flexibility, self-compassion, and intrinsic motivation (Stoeber & Otto, 2006). Maladaptive perfectionism, or perfectionistic concerns, encompasses excessive self-criticism, ruminative concern with past mistakes, and the experience of achievement as temporarily alleviating rather than genuinely satisfying. Meta-analytic evidence indicates that while perfectionistic strivings are associated with relatively modest positive outcomes in some domains, perfectionistic concerns are robustly associated with depression, anxiety, eating pathology, and suicidality across diverse populations (Limburg et al., 2017).

Digital environments have introduced qualitatively new mechanisms through which perfectionistic standards are activated, transmitted, and maintained. The concept of digital perfectionism, referring to the application of perfectionistic standards to one's online presentations and activities, has gained increasing scholarly attention (Sedera & Lokuge, 2020). Social media platforms reward the presentation of idealized self-images through quantified social approval in the form of likes, shares, and followers, creating powerful reinforcement contingencies that sustain perfectionistic online behavior. The permanence and publicness of digital records amplifies the psychological stakes of errors and imperfections. The temporal immediacy of digital communication creates expectations of perfect responsiveness that would be inconceivable in face-to-face interaction. And the algorithmic amplification of extreme presentations means that the social comparisons enabled by these platforms are systematically skewed toward the exceptional and ideal.

Clinical observations and empirical research converge on identifying several behavioral manifestations of digital perfectionism. These include compulsive editing and re-editing of social media posts and messages before sending; distress upon receiving fewer-than-expected social approval signals; excessive time spent curating profile images; avoidance of posting due to fear of imperfect presentation; and hypervigilance regarding others' responses or lack thereof. These behaviors, while individually minor, collectively constitute a pattern of sustained psychological effort and vigilance that generates significant distress over time and that may serve to reinforce underlying perfectionistic schemas rather than to resolve them (Egan et al., 2011).

Suicide Risk: Concepts, Epidemiology, and Moderating Factors

Suicidal behavior encompasses a spectrum from passive ideation through active planning, preparatory behaviors, nonfatal attempts, and completed suicide. This heterogeneity has important implications for research and clinical practice, as the risk factors and mechanisms that distinguish individuals at different points on this spectrum are not uniform. Contemporary frameworks for understanding suicidal behavior have moved beyond simple stress-diathesis models toward more dynamic accounts that emphasize the interaction of distal vulnerabilities and proximal precipitants within specific developmental, social, and environmental contexts (O'Connor & Nock, 2014).

Epidemiologically, the global burden of suicidal behavior is substantial. WHO (2021) estimates approximately 700,000 suicide deaths annually, with suicide ranking as the fourth leading cause of death among 15 to 29 year olds globally. Nonfatal attempts are estimated to be 20 times more frequent than deaths. Suicidal ideation, encompassing thoughts of wishing to be dead through to specific plans and intentions, is substantially more prevalent still, with lifetime prevalence estimates in the range of 9% to 15% in population-based studies (Nock et al., 2008). Critically for present purposes, rates of suicidal ideation and behavior among adolescents and young adults have shown concerning increases in many high-income countries over the past decade, a trend that has been temporally correlated, though not definitively causally linked, with the rise of social media use (Twenge et al., 2018).

Among the psychological models that have most influenced contemporary understanding of suicide, the Interpersonal Theory of Suicide (Van Orden et al., 2010) has attracted particular empirical support. This theory proposes that the most proximal psychological state preceding suicidal behavior is the simultaneous experience of thwarted belongingness, the perception that one is not genuinely connected to and valued by others, and perceived burdensomeness, the belief that one constitutes a burden to others that would be relieved by one's death. The model further proposes that the capability for suicide, encompassing reduced fear of death and increased pain tolerance acquired through habituation to aversive experiences, must also be present for ideation to translate into action. Digital environments interface with this model at multiple points: social media use can both satisfy and frustrate belonging needs, reinforce perceptions of burdensomeness through negative social comparison, and habituate users to disturbing content in ways that may incrementally increase acquired capability.

Joiner's (2005) model was complemented by the Integrated Motivational-Volitional (IMV) model proposed by O'Connor (2011), which provides a more granular account of the factors that drive the transition from suicidal ideation to action. The IMV model identifies a set of volitional moderators, including impulsivity, access to means, planning, and rehearsal, that determine whether the motivation to die translates into suicidal behavior. Within this framework, perfectionism operates primarily as a defeat and entrapment state, amplifying the sense of being trapped in an unacceptable situation from which no escape is visible other than death. Digital stress operates as both a triggering stressor and a context that modifies the availability of volitional moderators.

Biological Approaches: Neurobiology, HPA Axis, and Immunopsychiatry

Neuroendocrine Dysregulation and the HPA Axis

The hypothalamic-pituitary-adrenal (HPA) axis constitutes the primary neuroendocrine stress response system, orchestrating the release of cortisol in response to perceived threat. Under normal conditions, cortisol exerts negative feedback on the HPA axis, terminating the stress response and restoring homeostasis. Chronic stress disrupts this regulatory mechanism through multiple pathways, including downregulation of glucocorticoid receptor expression in the hippocampus and prefrontal cortex, and progressive sensitization of amygdalar threat-detection circuitry (McEwen, 2007). The result is sustained HPA axis hyperactivation and elevated basal cortisol, a physiological signature that has been consistently documented in individuals with depression and suicidal behavior (Pfennig et al., 2005).

The relevance of these mechanisms to digital stress is beginning to be established. Experimental studies have demonstrated that social evaluation threats, including negative social feedback delivered via digital platforms,

activate HPA axis stress responses comparable to those observed in classical social stress paradigms (Slavich & Irwin, 2014). For individuals with perfectionistic tendencies, whose self-worth is particularly contingent on performance and social evaluation, the near-continuous social evaluation context created by social media engagement may constitute a form of chronic low-grade HPA axis activation with cumulative pathophysiological consequences. Cortisol dysregulation, in turn, exerts downstream effects on hippocampal neurogenesis, prefrontal executive function, and the regulation of mood, all of which contribute to suicide risk.

Brain-Derived Neurotrophic Factor and Neuroplasticity

Brain-derived neurotrophic factor (BDNF) is a neurotrophin that plays essential roles in the development, maintenance, and plasticity of neural circuits subserving mood regulation, stress resilience, and executive function. Chronic stress reliably suppresses BDNF expression in the hippocampus and prefrontal cortex, with consequences for neurogenesis, synaptic plasticity, and the structural integrity of these regions (Duman & Monteggia, 2006). Post-mortem studies of suicide completers have documented reduced BDNF expression in the prefrontal cortex and hippocampus relative to non-suicide controls, providing direct evidence of BDNF's relevance to suicidal behavior (Dwivedi et al., 2003).

A functional polymorphism in the BDNF gene, the Val66Met variant, has been extensively studied as a moderator of stress-outcome relationships. The Met allele impairs activity-dependent BDNF secretion, resulting in reduced hippocampal volume and increased vulnerability to the effects of adversity on depressive and suicidal outcomes (Kaufman et al., 2006). In adolescents specifically, this polymorphism has been shown to moderate the relationship between environmental stressors and suicidal ideation, consistent with a gene-environment interaction model. While no study has yet specifically examined whether digitally mediated stressors interact with BDNF Val66Met genotype in predicting suicidal outcomes, the theoretical case for such an interaction is strong given the established associations between each element.

Neuroinflammation and Immunopsychiatry

The immunopsychiatric perspective on suicidal behavior has gained substantial momentum over the past decade. Elevated levels of pro-inflammatory cytokines, including interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-alpha), and C-reactive protein (CRP), have been documented in individuals with suicidal ideation and behavior independent of comorbid depression, suggesting a direct inflammatory contribution to suicidality (Courtet et al., 2015). The mechanisms through which inflammation influences suicidal behavior are multiple: inflammatory cytokines alter serotonin metabolism by upregulating tryptophan-catabolizing enzymes; they disrupt glutamatergic neurotransmission; and they impair the function of prefrontal regulatory circuits through direct neuroinflammatory effects.

Social stress, including social rejection, exclusion, and negative evaluation, is a potent activator of inflammatory signaling pathways (Slavich & Irwin, 2014). The social threat model of depression and inflammation posits that evolutionarily conserved threat-detection systems interpret social adversity as signaling increased risk of physical harm, triggering preparatory inflammatory responses. In the context of digital social environments, where social comparison, rejection, and exclusion occur at high frequency and are often unpredictable and ambiguous in their meaning, these pathways may be chronically activated. Perfectionism amplifies this dynamic by increasing the range of stimuli that are appraised as social threats, effectively widening the net of experiences that trigger inflammatory responses.

Table 2 Biological Pathways Linking Digital Stress and Perfectionism to Suicide Risk

Biological System	Effect of Chronic Digital Stress	Effect of Maladaptive Perfectionism	Relevance to Suicide Risk
HPA Axis	Sustained cortisol elevation; receptor downregulation	Amplified threat appraisal; chronic activation	Hippocampal atrophy; impaired executive function
BDNF / Neuroplasticity	Suppressed BDNF in PFC and hippocampus	Stress sensitization via Val66Met interaction	Reduced neural resilience; mood dysregulation

Neuroinflammation	Cytokine activation via social threat pathways	Widened threat appraisal; chronic inflammatory load	Altered serotonin metabolism; glutamate dysfunction
Serotonin System	5-HIAA reduction; receptor dysregulation	Impulsivity amplification under failure conditions	Impulsive suicidal behavior; lethal intent
Prefrontal Circuitry	Executive function impairment; rumination circuits	Cognitive inflexibility; negative self-schema activation	Failure of inhibitory control over suicidal impulse

Note. PFC = prefrontal cortex; HPA = hypothalamic-pituitary-adrenal; BDNF = brain-derived neurotrophic factor.

Psychological Approaches: Cognitive-Behavioral, Emotion Regulation, and Coping

Cognitive Vulnerabilities and Schema Activation

Cognitive models of suicidality emphasize the role of specific thought patterns and information-processing biases in elevating suicide risk. Beck's cognitive model identifies hopelessness, the generalized expectation that the future holds no positive possibilities, as the most proximal cognitive antecedent of suicidal behavior, more strongly predictive than depressive severity per se (Beck et al., 1990). Perfectionism contributes to hopelessness through multiple pathways: by setting standards that are inherently unattainable, it creates conditions in which the experience of failure is chronic and inescapable; by framing worth as contingent on performance, it ensures that failure is experienced as total rather than partial; and by precluding self-compassion as a response to failure, it forecloses the psychological recovery processes that might otherwise interrupt the descent toward hopelessness.

Digital environments introduce specific cognitive mechanisms that interact with perfectionism. The social comparison enabled by social media activates self-discrepancy theory's distinction between actual, ideal, and ought selves (Higgins, 1987). Continuous exposure to idealized presentations of peers' lives activates actual-ideal discrepancies, generating dejection-related emotions; the perception that others' standards require perfection activates actual-ought discrepancies, generating agitation-related emotions. For perfectionistic individuals, both types of discrepancy are chronically activated, creating a double burden of emotional distress. Research by Vogel et al. (2014) and subsequent work by Fardouly et al. (2015) has documented the specific contribution of appearance-related social comparisons on platforms such as Instagram to negative body image and self-esteem, constructs that are themselves associated with suicidal risk in adolescent and young adult populations.

Emotion Regulation and Affective Dysregulation

Emotion regulation, broadly defined as the processes by which individuals influence the emotions they experience, when they experience them, and how they express them, is a central moderator of the relationship between stress and psychopathology (Gross, 2015). Maladaptive perfectionism has been consistently associated with dysfunctional emotion regulation strategies including rumination, suppression, and avoidance, and with deficits in adaptive strategies including reappraisal and acceptance. Experimental research has demonstrated that inducing failure experiences in perfectionism-prone individuals results in greater affective dysregulation and more prolonged negative affect than in individuals with lower perfectionistic tendencies (Spasojevic & Alloy, 2001).

Digital environments present particular challenges for emotion regulation. The constant availability of digital stimuli creates opportunities for the use of digital technology as an avoidant coping strategy, providing momentary distraction from aversive internal states without addressing their sources. This pattern of avoidant digital coping has been associated with problematic internet use and with paradoxical increases in distress over time as avoided emotions accumulate without processing (Hormes et al., 2014). For perfectionistic individuals, the digital environment simultaneously generates distressing social comparison experiences and provides an avoidant coping medium that prevents adaptive processing, creating a self-perpetuating cycle. The specific neural mechanisms supporting these patterns include hyperactivation of amygdalar threat circuitry and

hypoactivation of prefrontal regulatory networks, a configuration associated with difficulty tolerating negative affect and with impulsive responding under conditions of emotional distress.

Interpersonal Mechanisms and Social Disconnection

Interpersonal factors constitute a central element of most contemporary models of suicidal behavior. As reviewed above, the Interpersonal Theory of Suicide identifies thwarted belongingness and perceived burdensomeness as the proximal psychological states most strongly associated with suicidal desire. Digital social environments interact with these constructs in complex and often paradoxical ways. On one hand, digital communication technologies expand the potential for social connection, allow maintenance of geographically distant relationships, and provide access to communities of shared interest and experience that may not be available locally. On the other hand, research suggests that passive social media use, characterized by scrolling and observing without active engagement, is associated with increased feelings of social exclusion and diminished belonging, particularly when the content encountered portrays others' rich social lives in contrast to one's own perceived isolation (Fardouly et al., 2015; Coyne et al., 2020).

Perfectionism interacts with these dynamics through its effects on both the quality of social relationships and the processing of social information. Research by Hewitt et al. (2006) has documented that socially prescribed perfectionism, in particular, is associated with concealment of perceived imperfections in social relationships, avoidance of authentic self-disclosure, and chronic vigilance for evidence of others' evaluative judgments. These interpersonal patterns undermine the development of genuine intimacy and belonging, creating the conditions for thwarted belongingness even in the presence of nominally extensive social networks. In digital contexts, where social interaction is structured around curated presentations and quantified approval metrics, these patterns are likely to be amplified.

Genetic and Genomic Perspectives: Heritability, Polygenic Risk, and Gene-Environment Interactions

Heritability of Suicidal Behavior

Family, twin, and adoption studies have established that suicidal behavior is substantially heritable, with heritability estimates ranging from 30% to 55% depending on the population studied and the specific phenotype examined (Brent & Mann, 2005). Heritability estimates are highest for completed suicide and somewhat lower for ideation and attempts, consistent with the view that the genetic liability to suicidal behavior is partially distinct from the genetic liability to suicidal thinking. Family studies indicate that a positive family history of suicide is among the most robust predictors of suicide risk at the individual level, conferring approximately a fourfold increase in risk after adjustment for shared environmental factors (Qin et al., 2002).

The mechanisms through which genetic factors influence suicide risk are heterogeneous. Part of the heritable component is mediated by the heritability of psychiatric disorders that are themselves major risk factors for suicide, including major depression, bipolar disorder, schizophrenia, and substance use disorders. However, evidence from family and twin studies indicates that genetic liability to suicidal behavior is not entirely reducible to liability to these disorders, suggesting the existence of suicide-specific genetic factors. Current candidates include variants influencing serotonergic neurotransmission, HPA axis reactivity, impulsivity and aggression regulation, and stress response systems (Willour et al., 2012).

Genome-Wide Association Studies and Polygenic Risk

The advent of genome-wide association studies (GWAS) has enabled systematic searches for common genetic variants associated with suicidal behavior at scale. To date, several large GWAS have been conducted for suicidal ideation and attempts, with the largest, based on data from the UK Biobank and Million Veteran Program, achieving sample sizes sufficient to detect loci of small effect (Ruderfer et al., 2020). While no single locus has achieved robust and replicable genome-wide significance across independent samples, polygenic risk score (PRS) analyses have demonstrated that the aggregate genetic risk for depression, anxiety, and suicidal behavior, as estimated from GWAS summary statistics, is meaningfully predictive of suicidal outcomes at the individual level (Joo et al., 2022).

Polygenic approaches have also revealed substantial genetic overlap between suicidal behavior and related phenotypes, including major depression, attention deficit hyperactivity disorder, post-traumatic stress disorder, and various dimensions of personality including neuroticism. This genetic architecture is consistent with a transdiagnostic liability to broad internalizing psychopathology within which suicidal behavior represents an extreme expression. For perfectionism, twin studies have estimated heritability in the range of 30% to 50%, and there is growing interest in identifying specific genetic variants that contribute to this heritability (Tozzi et al., 2004). To date, no GWAS of perfectionism has achieved sufficient power for genome-wide significant findings, but preliminary analyses suggest overlap with genetic variants associated with anxiety, conscientiousness, and neuroticism.

Epigenetics and Gene-Environment Interactions

Epigenetic mechanisms, encompassing DNA methylation, histone modification, and non-coding RNA regulation, provide a molecular interface between genetic predispositions and environmental experiences. Adversity-induced epigenetic modifications can alter gene expression in ways that are partially heritable across generations, offering one explanation for the intergenerational transmission of stress vulnerability (McGowan et al., 2009). Of particular relevance to suicide research, post-mortem studies have documented altered methylation of the glucocorticoid receptor gene promoter in the hippocampal tissue of suicide completers with a history of early childhood abuse, compared to controls, suggesting that early adversity leaves epigenetic signatures that persist into adulthood and contribute to HPA axis dysregulation and suicide risk (McGowan et al., 2009).

The question of whether digitally mediated stressors can induce epigenetic modifications comparable to those observed following early childhood adversity is theoretically important and empirically underexplored. The existing literature does not yet permit definitive conclusions, but several observations are relevant. First, the HPA axis activating and neuroinflammatory consequences of social stress, including digitally mediated social stress, are now well established. Second, sustained HPA axis activation is itself capable of inducing epigenetic modifications at glucocorticoid-responsive loci. Third, the developmental timing of digital stress exposure, with adolescence representing a period of heightened neurobiological sensitivity and epigenetic plasticity, suggests that early and sustained digital stress exposure may carry particular epigenetic risk. Prospective longitudinal studies with epigenetic endpoints are needed to test these possibilities directly.

Table 3 Genetic and Epigenetic Factors in the Digital Stress-Perfectionism-Suicide Model

Genetic/Epigenetic Factor	Evidence Base	Putative Mechanism	Research Priority
BDNF Val66Met polymorphism	Moderates stress-suicidality associations in adolescents (Kaufman et al., 2006)	Impaired activity-dependent BDNF secretion; reduced hippocampal neuroplasticity	Test interaction with digital stress exposure
5-HTTLPR serotonin transporter variant	Moderates depression risk under stress (Caspi et al., 2003)	Reduced serotonin reuptake efficiency; mood dysregulation	Examine in context of social media social comparison
Polygenic risk scores	Predict suicidal behavior across developmental stages (Joo et al., 2022)	Aggregated common variant effects on neural stress circuitry	Integrate with digital phenotyping data
NR3C1 glucocorticoid receptor methylation	Elevated in suicide completers with childhood adversity (McGowan et al., 2009)	HPA axis dysregulation via altered receptor expression	Examine in digitally stressed adolescent samples
Perfectionism heritability	30-50% estimated from twin studies (Tozzi et al., 2004)	Shared genetic pathways with neuroticism and anxiety	GWAS with sufficient power needed

Note. GWAS = genome-wide association study; HPA = hypothalamic-pituitary-adrenal; BDNF = brain-derived neurotrophic factor.

Intersections: How Digital Stress and Perfectionism Converge to Influence Suicide Risk

The preceding sections have reviewed digital stress, perfectionism, and suicidal behavior as relatively distinct domains. The present section considers how these constructs interact and reinforce one another, with specific attention to the mechanisms through which their convergence generates elevated suicide risk. We propose a tripartite biopsychosocial model in which digital stress and perfectionism function as mutually amplifying risk factors operating through shared and partially independent biological, psychological, and genetic pathways.

At the biological level, the convergence of digital stress and perfectionism generates a pattern of chronic neuroendocrine and neuroinflammatory activation that exceeds the pathophysiological burden of either factor alone. Perfectionism amplifies the appraisal of digital stimuli as threatening, increasing HPA axis responses to social evaluation events that might be appraised more neutrally by less perfectionistic individuals. Chronic digital engagement, by sustaining near-continuous exposure to social evaluation cues, ensures that this amplified stress response is perpetually activated rather than episodic. The cumulative neurobiological consequence is a progressive erosion of the neural resilience mechanisms, including hippocampal neurogenesis, BDNF signaling, and prefrontal regulatory capacity, that normally buffer against the translation of stressful experience into suicidal ideation and behavior.

At the psychological level, perfectionism and digital stress interact through mutually reinforcing cycles of cognitive and behavioral dysregulation. The social comparison opportunities afforded by digital platforms provide continuous activation of perfectionistic standards and schemas, while perfectionism amplifies the distress generated by unfavorable comparisons. Compulsive digital checking behaviors, driven by perfectionism's demand for monitoring and control, generate further information overload and intrusion. Avoidant digital coping, in which technology is used as a distraction from the distress it also generates, prevents the adaptive emotional processing that might otherwise interrupt these cycles. The net effect is a sustained state of cognitive preoccupation, emotional dysregulation, and behavioral inflexibility that is highly consistent with the psychological profiles of individuals at elevated suicide risk.

At the genetic level, individuals carrying polygenic risk profiles for both suicidal behavior and stress-reactive neurobiological systems may be disproportionately vulnerable to the combined effects of digital stress and perfectionism. Gene-environment interaction models predict that the pathological effects of adverse environments are most pronounced in individuals with relevant genetic vulnerabilities. For digital stress, this implies that the neurobiological consequences of sustained social media exposure and continuous connectivity are not uniformly distributed across the population but are concentrated in individuals whose genetic endowment makes them particularly sensitive to social-evaluative threats and stress-induced neurobiological dysregulation. Epigenetic mechanisms may further amplify these effects, particularly when digital stress exposure occurs during sensitive developmental periods characterized by heightened neurobiological plasticity.

A structural model integrating these pathways would specify digital stress as an environmental exposure that activates both perfectionistic concerns (through social comparison and social evaluation mechanisms) and direct neurobiological stress responses (through techno-overload and invasion mechanisms). Perfectionism would function as both a consequence of digital stress and an amplifier of its pathological effects, with maladaptive perfectionism mediating a substantial portion of the relationship between digital stress and suicidal ideation. Genetic and neurobiological vulnerabilities would function as moderators, determining the magnitude of both the direct and perfectionism-mediated pathways. Protective factors including adaptive coping, social support, and psychological flexibility would moderate these pathways, consistent with a resilience-integrated model.

Methodological Considerations: Measurement, Study Designs, and Ethical Implications

Measurement Challenges

Methodological rigor in this field requires careful attention to the measurement of each constituent construct. Digital stress presents particular challenges because existing instruments vary substantially in their conceptualization of the construct, with some focusing primarily on technostress dimensions, others on social

media-specific pressures, and others on FoMO or problematic use. The Digital Stress Scale developed by Reinecke et al. (2017) represents a significant advance in providing a validated multidimensional instrument with established psychometric properties, but its applicability across age groups, cultural contexts, and specific digital environments requires further testing. Ecological momentary assessment (EMA) methods, in which digital stress is measured multiple times per day in naturalistic contexts using smartphones, offer methodological advantages over retrospective self-report while introducing their own challenges around participant burden and reactivity effects.

Perfectionism measurement has benefited from decades of psychometric development, with the Frost Multidimensional Perfectionism Scale (FMPS; Frost et al., 1990) and the Hewitt and Flett Multidimensional Perfectionism Scale (HMPS; Hewitt & Flett, 1991) remaining the most widely used instruments. More recent work has highlighted the importance of measuring perfectionism at the behavioral level, capturing the specific patterns of digital behavior through which perfectionistic tendencies are expressed, rather than relying exclusively on trait-level self-report. Digital behavioral data, including posting frequency, editing behaviors, engagement patterns, and response time distributions, may offer objective behavioral signatures of digital perfectionism that complement self-report measures.

Study Design Considerations

Cross-sectional research, which constitutes the majority of existing work in this area, is inadequate to resolve questions about the temporal and causal relationships among digital stress, perfectionism, and suicidal behavior. Longitudinal designs with repeated measurement are essential for establishing the direction of effects and the developmental trajectories through which these relationships unfold. Experience sampling and ecological momentary assessment designs are particularly well suited to capturing the dynamic, fluctuating nature of digital stress and its within-person relationships with mood, cognition, and suicidal ideation. Experimental approaches, including laboratory paradigms that induce digital stress or prime perfectionistic concerns, provide mechanistic evidence and allow causal inference in controlled conditions, though their generalizability to naturalistic contexts must be carefully evaluated.

The integration of biological measures with psychological and behavioral data represents both a significant opportunity and a substantial methodological challenge. Ambulatory cortisol assessment using salivary samples collected at multiple time points provides ecologically valid indicators of HPA axis functioning that can be linked to digital behavior patterns. Neuroimaging studies have begun to characterize the neural correlates of responses to social media stimuli, but sample sizes in existing studies are typically insufficient for robust findings and replication. Large-scale biobank studies that combine genetic data with digital phenotyping, ecological momentary assessment, and clinical outcomes represent the frontier of methodological development in this field.

Ethical Considerations

Research in this area raises important ethical considerations that merit explicit attention. The collection of digital behavioral data for research purposes requires careful attention to privacy, informed consent, and data security. Suicidal ideation and behavior are sensitive outcomes that require ethical protocols for managing disclosure and ensuring participant safety. Research involving adolescents, who constitute a particularly vulnerable population in this context, requires additional safeguards including parental consent procedures and age-appropriate study designs. The potential for research findings to be misappropriated, for example in the commercial optimization of social media platforms in ways that exploit psychological vulnerabilities, represents an ethical challenge at the boundary between science, technology, and policy that the field has not yet adequately addressed.

Prevention and Intervention: Evidence-Based Strategies in Clinical and Digital Contexts

Psychotherapeutic Approaches

Cognitive behavioral therapy (CBT) represents the most extensively evaluated psychological intervention for both perfectionism and suicidal behavior, with substantial evidence bases supporting its efficacy in each

domain. CBT for perfectionism, as manualized by Shafran et al. (2010), targets the cognitive schemas and behavioral patterns that maintain maladaptive perfectionism through a combination of cognitive restructuring, behavioral experiments, and self-compassion training. Randomized controlled trials have demonstrated clinically meaningful reductions in perfectionism, depression, and anxiety following CBT-based interventions, with effects maintained at follow-up (Egan et al., 2014). Adaptations of CBT for delivery via digital platforms, including therapist-guided online programs and self-directed apps, have demonstrated comparable efficacy to face-to-face delivery for mild to moderate presentations, with particular advantages in terms of reach and accessibility (Topooco et al., 2017).

Dialectical behavior therapy (DBT), originally developed for individuals with borderline personality disorder and chronic suicidality, has been adapted for use with adolescents and has demonstrated efficacy in reducing suicidal ideation, self-harm, and suicide attempts in randomized controlled trials (Mehlum et al., 2014). DBT's emphasis on dialectical thinking, mindfulness, and emotion regulation skills makes it particularly well suited to addressing the cognitive inflexibility, emotion dysregulation, and interpersonal difficulties that characterize the intersection of perfectionism and digital stress. Skills training in distress tolerance and interpersonal effectiveness may be especially relevant to the management of digitally induced social stress and the perfectionism-maintaining patterns of digital behavior described above.

Digital and Technology-Based Interventions

The same digital technologies that contribute to stress and perfectionism also offer significant potential as platforms for preventive and therapeutic intervention. Internet-delivered mental health interventions have expanded dramatically in both variety and evidence base over the past decade. Meta-analytic reviews indicate that internet-delivered CBT is efficacious for depression, anxiety, and related conditions, with effect sizes that, while somewhat smaller than those achieved in face-to-face delivery, are clinically meaningful and substantially more accessible (Andersson et al., 2014). For adolescent populations specifically, internet-delivered and app-based programs targeting stress, self-esteem, and wellbeing have demonstrated promise in reducing risk factors for suicidal behavior, though rigorous evaluations specifically targeting the digital stress-perfectionism pathway remain limited.

Mindfulness-based digital interventions represent a growing area of development and evaluation. Mindfulness practices directly target several of the psychological mechanisms linking digital stress and perfectionism to suicide risk, including rumination, experiential avoidance, self-critical thinking, and emotion dysregulation. App-based mindfulness programs, including Headspace and Calm, have reached enormous user populations, though the evidence base for their efficacy in high-risk populations is less well developed than that for structured internet-delivered CBT. The integration of mindfulness skills training specifically targeting digital stress, for example through mindful technology use practices that interrupt compulsive checking behaviors and promote intentional engagement with digital content, represents a promising but underexplored intervention approach.

School-Based and Universal Prevention

Universal prevention programs delivered in school settings represent an important complement to targeted clinical interventions, given the high prevalence of subclinical digital stress and perfectionism in adolescent populations and the potential for early intervention to interrupt the developmental trajectories through which these vulnerabilities solidify into clinical presentations. Programs such as MindMatters in Australia, the Penn Resilience Program, and the Positive Education Schools Association (PESA) curriculum have demonstrated efficacy in building psychological resilience, reducing depressive symptoms, and improving wellbeing in school-aged populations (Brunwasser et al., 2009). Adaptation of these programs to specifically address digital stress, social media literacy, and perfectionistic thinking in digital contexts represents a priority for prevention science.

Media literacy education, which equips young people with critical skills for evaluating and contextualizing digital content, represents another promising prevention approach. Programs that teach adolescents to recognize the curated and potentially misleading nature of social media presentations, to understand the

algorithmic mechanisms that drive extreme content amplification, and to develop conscious and intentional rather than compulsive patterns of digital engagement may reduce the social comparison and information overload mechanisms through which digital stress generates its adverse effects. Several randomized controlled trials of media literacy programs have demonstrated reductions in social comparison activity and improvements in body image and self-esteem (McLean et al., 2015), though effects on perfectionism and suicidal outcomes specifically remain to be demonstrated.

Policy and Public Health Implications: Education, Screening, and Access to Care

The evidence reviewed in this paper has implications that extend well beyond the clinical encounter, reaching into the domains of public health infrastructure, educational policy, and technology regulation. The scale of the digital stress phenomenon, its cross-cutting effects on perfectionism and suicidal behavior, and its disproportionate impact on young populations place it squarely within the purview of population-level public health intervention. At the same time, the individual-level biological, psychological, and genetic factors that moderate its effects underscore the continued importance of targeted clinical services for high-risk individuals.

Educational policy represents perhaps the most immediate domain for impactful intervention. Schools are the principal institution through which public health messages reach young populations, and their capacities for universal screening, early identification, and first-level intervention are substantially underutilized in the context of digital stress and perfectionism. The integration of digital literacy curricula, social-emotional learning programs, and universal mental health screening protocols into routine educational practice would substantially extend the reach of evidence-based prevention. Teacher training in the recognition of warning signs of digital stress, maladaptive perfectionism, and suicidal risk is an essential enabling condition for this expanded role, and requires investment in professional development that has not been adequately prioritized in most jurisdictions.

Technology regulation is an increasingly prominent but contested domain of policy. The past several years have seen growing legislative interest in restricting social media access for minors, mandating transparency in algorithmic content curation, and imposing liability on platforms for documented harms associated with their products. The scientific evidence base for these regulatory approaches is developing but not yet sufficient to specify the precise forms of regulation most likely to be effective. The challenges of platform diversity, cross-border regulatory authority, and the risk of driving problematic use to less regulated platforms complicate regulatory strategy. Nevertheless, the direction of evidence consistently supports the proposition that current social media architectures optimize for engagement at the expense of wellbeing, and that regulatory and design interventions that rebalance these priorities could yield meaningful public health benefits (Rideout & Fox, 2018).

Access to mental health care remains a fundamental determinant of outcomes for individuals at elevated suicide risk. Digital stress and perfectionism, as emerging risk factors, are inadequately addressed in existing clinical training and service delivery frameworks. The integration of these constructs into routine clinical assessment protocols, the training of primary care and school health providers in their recognition and initial management, and the development of stepped care pathways that provide timely access to appropriate levels of intervention are essential system-level priorities. Telehealth models, which have expanded significantly in the wake of the COVID-19 pandemic, offer important opportunities to extend access to evidence-based care to underserved populations and to integrate digital wellbeing support into routine health care delivery.

CONCLUSION

This paper has provided a comprehensive examination of the relationships among digital stress, perfectionism, and suicidal behavior, integrating biological, psychological, and genetic perspectives within a unified biopsychosocial framework. The evidence reviewed supports several overarching conclusions. First, digital stress is a clinically meaningful construct with real and measurable consequences for mental health, operating through multiple mechanisms including social comparison, information overload, sleep disruption, and HPA axis activation. Second, perfectionism, particularly in its maladaptive and socially prescribed variants, is substantially amplified by digital environments and functions as both an outcome of digital stress and an

amplifier of its pathological effects. Third, the convergence of digital stress and perfectionism creates compounding risks for suicidal ideation and behavior through shared and partially independent biological, psychological, and genetic pathways. Fourth, these pathways are moderated by genetic vulnerabilities, developmental timing, and protective factors, underscoring the importance of personalized and developmentally sensitive approaches to both research and intervention.

The field faces significant methodological challenges, including the need for longitudinal and experimental designs, the integration of biological and behavioral measures, and the development of validated instruments that adequately capture the novel dimensions of digital stress and digital perfectionism. Progress on these methodological fronts is essential for advancing causal understanding and for developing the evidence base needed to guide effective intervention.

From a translational perspective, the most urgent priorities include the development and evaluation of digital interventions that specifically target the convergence of digital stress and perfectionism, the integration of digital literacy and social-emotional learning into educational curricula, and the creation of clinical screening protocols that assess these risk factors as part of routine mental health evaluation. At the policy level, attention to technology design, regulatory frameworks, and health system capacity to address these emerging risks is urgently needed.

The broader significance of this work lies in its contribution to understanding the psychological and neurobiological consequences of digital modernity. As digital technologies continue to reshape the conditions of human social life, the mental health consequences of this transformation will become an increasingly central concern for clinical science, public health, and policy. A rigorous, multidisciplinary, and ethically grounded approach to these questions is not merely academically important; it is a matter of substantial human welfare.

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