Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

Beyond Neurotransmitters: Integrating Biological, Structural, and Digital Determinants in Contemporary Psychiatry

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Received: 26-Feb-2026 | **Accepted:** 26-Feb-2026 | **Published:** 28-Feb-2026

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How to cite this article: Valero, J. J., de la Torre Bustamante, M. M., Jimenez Silva, S., López Coyoy, H. D., Gómez Cañupil, G. I., Vega Vásquez, V. H., Madroñero Basante, D. M., & Che Enseñat, J. (2026). Beyond Neurotransmitters: Integrating Biological, Structural, and Digital Determinants in Contemporary Psychiatry. México. International Science Journal "TheSci". 3 (1) 246-265. Quality Consulting Instituto de Educación Capacitación y Certificación de México. https://ieccmexico.com/thesci

ABSTRACT

Mental health disorders represent a leading cause of disability worldwide and require integrative frameworks that transcend traditional single-domain explanations. This review analyzes the neurobiological, social, and digital dimensions of psychiatric disorders through a structured synthesis of international literature. Neurobiological evidence highlights circuit-level dysfunction, stress-mediated neuroplasticity, inflammatory pathways, and gut–brain interactions as core vulnerability mechanisms. Social epidemiology research demonstrates that income gradients, structural inequality, and hierarchical stress responses shape population-level distribution of mental morbidity. Concurrently, digital environments function as both intervention platforms and behavioral risk modifiers, with smartphone-based tools showing therapeutic potential while excessive screen exposure and maladaptive social media engagement correlate with adverse outcomes. The findings support a multidimensional systems-based model

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

in which biological substrates, structural determinants, and technological ecosystems interact dynamically. This framework holds particular relevance for middle-income contexts, including Mexico, Colombia, and Ecuador, where rapid digitalization coexists with socioeconomic disparities. Integrating these domains strengthens clinical reasoning, psychiatric education, and public health strategy design, promoting a comprehensive and ethically guided approach to contemporary mental health care.
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KEYWORDS

Mental health disorders, neurobiology, social determinants, digital psychiatry, neuroinflammation, stress physiology, digital phenotyping, socioeconomic inequality, smartphone interventions, global mental health

INTRODUCTION

Mental health disorders represent one of the most pressing public health challenges of the twenty-first century. Epidemiological data consistently demonstrate their high lifetime and 12-month prevalence across populations, affecting individuals regardless of age, gender, or socioeconomic status [2]. Beyond their frequency, mental and substance use disorders account for a substantial proportion of global disability, contributing significantly to years lived with disability worldwide [3]. The World Health Organization (WHO) has emphasized that transforming mental health systems requires a comprehensive understanding of biological vulnerability, social determinants, and rapidly evolving technological contexts [11].

Historically, psychiatric research has oscillated between biological reductionism and purely psychosocial explanations. Contemporary models increasingly recognize that mental disorders emerge from the dynamic interaction between neurobiological mechanisms and environmental exposures. Advances in neuroscience have reshaped the understanding of severe mental illnesses such as schizophrenia, highlighting circuit-level dysfunction rather than isolated neurotransmitter imbalances [1]. Similarly, the neurobiology of depression has been extensively characterized in terms of monoaminergic dysregulation, neuroplasticity alterations, and stress-related structural changes in limbic regions [4]. The concept of intermediate phenotypes has further refined the bridge between genetic risk and clinical manifestation, suggesting that measurable neurocognitive or neurophysiological markers may mediate vulnerability [5].

Chronic stress is now recognized as a critical biological and systemic factor influencing mental health trajectories. Prolonged activation of the hypothalamic–pituitary–adrenal (HPA) axis can induce structural remodeling in the hippocampus and prefrontal cortex, thereby altering emotional regulation and cognitive control [6]. The "kindling" hypothesis proposes that recurrent mood episodes may sensitize neural circuits, lowering the threshold for future episodes and reinforcing chronicity [7]. In parallel, emerging evidence links neuroinflammation and immune dysregulation to psychiatric symptomatology, particularly in major depressive disorder and psychotic conditions [17], [18]. The bidirectional communication between the gut microbiota and the central nervous system—the so-called gut–brain axis—has introduced additional biological complexity, suggesting that microbial composition may influence mood, cognition, and stress responsiveness [16].

However, neurobiology alone does not sufficiently explain the distribution and expression of mental disorders. Social hierarchies, income inequality, and structural determinants exert measurable effects on mental health outcomes. Research on social status and stress physiology has demonstrated that perceived rank and chronic adversity influence endocrine responses and long-term health [8]. Income gradients are strongly associated with mental morbidity, reflecting broader patterns of social disadvantage [9]. Social epidemiology frameworks emphasize that health inequities are not merely individual-level phenomena but are embedded within political, economic, and historical structures [10]. These perspectives are particularly relevant for middle-income countries such as Mexico, Colombia,

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

and Ecuador, where socioeconomic disparities, urbanization, and exposure to violence intersect with limited mental health resources.

In recent years, a third dimension has gained increasing relevance: the digital environment. The rapid expansion of smartphones and social media platforms has reshaped interpersonal communication, identity formation, and access to health information. The digital revolution in mental health has opened new possibilities for scalable interventions, remote monitoring, and early detection [12]. Meta-analytic evidence suggests that smartphone-based interventions can produce modest but significant reductions in depressive and anxiety symptoms [13]. The concept of digital phenotyping proposes that passive data collection—such as activity patterns, geolocation, or typing speed—may serve as real-time behavioral biomarkers of psychiatric states [15].

Nevertheless, digital exposure is not inherently protective. Excessive screen time has been associated with increased depressive symptoms among adolescents [19], and systematic reviews have identified correlations between social media use and suicide-related outcomes in vulnerable populations [20]. Concerns regarding data privacy, transparency, and ethical governance of mental health applications remain substantial [14]. Thus, digital psychiatry simultaneously offers unprecedented opportunities and novel risks.

Given this evolving landscape, there is a pressing need for integrative frameworks that examine mental disorders across neurobiological, social, and digital domains. While prior studies have extensively explored each of these dimensions independently, fewer reviews have synthesized them within a single conceptual model that reflects contemporary global realities. This gap is particularly relevant for Latin American contexts, where rapid digitalization coexists with structural inequality and diverse cultural understandings of mental health. Collaborative academic initiatives in Mexico, Colombia, and Ecuador have increasingly emphasized interdisciplinary research that bridges neuroscience, public health, and digital innovation, underscoring the regional importance of this integrative approach.

The present review seeks to address the following research questions:

1. How do neurobiological mechanisms—including stress physiology, neuroinflammation, and microbiota–brain interactions—contribute to vulnerability and progression of mental health disorders?
2. In what ways do social determinants such as income inequality, social status, and structural inequities shape mental health outcomes?
3. How does digital exposure, including smartphone use and social media engagement, influence both risk and intervention strategies in contemporary psychiatry?

This review is grounded in a structured analysis of seminal and recent literature addressing these three domains. The design aligns with the guiding hypothesis that mental disorders are best understood as multifactorial conditions emerging from the interaction of biological susceptibility, social context, and digital environment. By synthesizing evidence from neuroscience, social epidemiology, and digital psychiatry, the article aims to provide an integrative framework suitable for academic training and international dialogue. The ultimate objective is to foster a multidimensional perspective that informs clinical practice, public health policy, and research collaboration across diverse settings.

DEVELOPMENT

1. Detailed Analysis of the Topic

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

1.1 Neurobiological Dimension of Mental Disorders

The neurobiological understanding of psychiatric disorders has evolved significantly over the past decades. Rather than being confined to isolated neurotransmitter deficiencies, contemporary research conceptualizes mental disorders as circuit-based dysfunctions involving distributed neural networks [1]. In schizophrenia, for instance, alterations in cortico-striatal-thalamic circuitry have been proposed as central mechanisms underlying cognitive fragmentation and psychotic symptoms [1]. This reconceptualization moves beyond simplistic dopamine hypotheses and incorporates genetic vulnerability, synaptic plasticity, and developmental neurobiology.

In major depressive disorder (MDD), structural and functional changes in the prefrontal cortex, hippocampus, and amygdala have been consistently reported [4]. Chronic stress exposure, through persistent activation of the hypothalamic–pituitary–adrenal (HPA) axis, induces glucocorticoid-mediated neurotoxicity and reduces neurogenesis, particularly in hippocampal regions [6]. These findings are clinically relevant, as they provide a biological explanation for cognitive impairment, emotional dysregulation, and recurrent symptom patterns.

The concept of sensitization or "kindling" further supports the progressive nature of mood disorders [7]. Repeated affective episodes appear to lower the threshold for subsequent relapses, suggesting cumulative neurobiological alterations over time. This model aligns with clinical observations in Latin American settings, where delayed access to care may contribute to recurrent, untreated episodes that reinforce neurobiological vulnerability.

In parallel, growing evidence links immune dysregulation to psychiatric symptomatology. Neuroinflammatory processes, characterized by microglial activation and elevated pro-inflammatory cytokines, have been observed in depressive and psychotic disorders [17]. Elevated inflammatory biomarkers in patients with MDD have been correlated with treatment resistance and symptom severity [18]. These findings suggest that mental disorders may involve systemic physiological processes beyond the central nervous system alone.

Moreover, the gut–brain axis introduces an additional layer of complexity. The intestinal microbiota influences neurochemical signaling through immune, endocrine, and vagal pathways [16]. Alterations in microbial diversity have been associated with anxiety, depression, and stress responsiveness, raising the possibility that nutritional and microbiome-targeted interventions could complement traditional pharmacotherapy.

Taken together, neurobiological evidence supports a multifactorial model in which genetic predisposition, stress physiology, immune signaling, and microbiota interactions converge to influence vulnerability and disease progression.

1.2 Social Determinants and Structural Context

While neurobiology provides insight into mechanisms, it does not fully explain population-level distribution of mental disorders. Social epidemiology emphasizes that mental health outcomes are shaped by socioeconomic gradients, political structures, and exposure to adversity [10].

Income inequality has a measurable association with mental morbidity [9]. Individuals in lower socioeconomic strata are disproportionately exposed to chronic stressors such as financial insecurity, unsafe neighborhoods, and limited access to healthcare. These structural stressors may amplify neurobiological vulnerability through sustained activation of stress pathways [6].

Research on social status and health demonstrates that perceived rank within social hierarchies influences physiological stress responses [8]. Chronic social subordination is associated with altered cortisol patterns and long-term health deterioration. In countries such as Mexico, Colombia, and Ecuador, where income disparities remain substantial, social determinants are deeply intertwined with psychiatric vulnerability.

The global burden of mental and substance use disorders underscores the magnitude of this challenge [3]. Despite high prevalence rates [2], access to mental health services in many middle-income nations remains insufficient. The WHO has emphasized the need for system-level transformation, including community-based models and integration into primary care [11].

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

These data support the argument that mental health cannot be reduced to individual pathology. Instead, it reflects the interaction between biological predisposition and structural context.

1.3 Digital Environment and Contemporary Psychiatry

The rapid digitalization of society has introduced both opportunities and risks for mental health. The digital revolution in psychiatry has enabled remote assessment, telepsychiatry, and mobile-based therapeutic interventions [12]. Meta-analytic evidence indicates that smartphone-based interventions can reduce depressive and anxiety symptoms, particularly when grounded in cognitive-behavioral frameworks [13].

Digital phenotyping proposes the use of passive smartphone data—such as movement patterns, typing behavior, and communication frequency—to detect early signs of relapse or symptom exacerbation [15]. This approach may be particularly valuable in regions with limited access to in-person psychiatric services, allowing scalable monitoring strategies.

However, digital exposure is not inherently beneficial. Excessive screen time among adolescents has been associated with increased depressive symptoms [19]. Furthermore, systematic reviews have linked problematic social media use with suicide-related outcomes in vulnerable individuals [20]. These findings are especially relevant in Latin America, where smartphone penetration has increased dramatically in the last decade.

Concerns regarding data privacy and transparency in mental health applications remain significant [14]. Ethical governance, regulatory frameworks, and culturally sensitive implementation are critical to ensuring that digital tools do not exacerbate inequality or compromise patient confidentiality.

Thus, the digital dimension must be integrated cautiously into psychiatric practice, balancing innovation with ethical safeguards.

1.4 Integrative Perspective

The convergence of neurobiological vulnerability, social determinants, and digital exposure supports a multidimensional model of mental disorders. Biological mechanisms explain susceptibility and symptom progression; social structures contextualize risk distribution; and digital environments reshape both exposure and intervention pathways.

For academic training in Mexico, Colombia, and Ecuador, this integrative perspective fosters a comprehensive understanding of psychiatric disorders that transcends disciplinary silos. It encourages clinicians and students to interpret symptoms not only through neurochemical lenses but also within social realities and technological ecosystems.

The synthesis of these three dimensions provides a contemporary framework for research, clinical decision-making, and public health policy in international contexts.

GENERAL OBJECTIVE AND SPECIFIC OBJECTIVES

To analyze and integrate the neurobiological, social, and digital dimensions of mental health disorders through a structured review of international evidence, in order to provide a multidimensional framework applicable to psychiatric education, clinical reasoning, and public health strategies in diverse contexts, including Mexico, Colombia, and Ecuador.

A. Cognitive Domain

1. **Remembering:**
    - Identify and describe key neurobiological mechanisms involved in mental health disorders, including stress physiology, neuroinflammation, genetic vulnerability, and gut–brain interactions [4], [6], [17], [16].

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
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Review International Science Journal

2. **Understanding:**
    - Explain how socioeconomic gradients and structural determinants influence mental health outcomes at the population level [9], [10].
3. **Applying:**
    - Apply integrative models to interpret clinical scenarios that involve biological, social, and digital risk factors simultaneously.
4. **Analyzing:**
    - Compare traditional neurochemical models of psychiatric disorders with circuit-based and systemic frameworks [1], [5].
5. **Evaluating:**
    - Critically assess the benefits and risks of digital mental health interventions, including ethical implications related to privacy and data governance [13], [14], [15].
6. **Creating:**
    - Develop a conceptual multidimensional model that synthesizes biological, social, and technological determinants of mental health disorders.

B. Psychomotor Domain

1. Conduct structured assessments that incorporate biological history, social determinants, and digital behavior patterns into psychiatric evaluation.
2. Utilize digital screening tools and mobile-based interventions responsibly within clinical practice.
3. Implement interdisciplinary case discussions that integrate neurobiological data with social context.
4. Design educational workshops or academic modules that promote multidimensional psychiatric reasoning among medical trainees.

C. Affective Domain

5. Demonstrate sensitivity toward the impact of socioeconomic inequality on mental health outcomes.
6. Promote ethical responsibility regarding digital data usage and patient confidentiality [14].
7. Value interdisciplinary collaboration between psychiatry, public health, neuroscience, and digital innovation.
8. Foster a humanistic approach that recognizes patients as individuals embedded within biological systems, social structures, and technological environments.

OBJECT OF STUDY

1. **Phenomenon under study**

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
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Review International Science Journal

- The phenomenon is the *multidimensional genesis and expression of mental health disorders*, understood as outcomes of interacting **neurobiological**, **social**, and **digital** factors rather than single-cause processes [3], [11].

2. **Core concept (central construct)**
   - Mental disorders are conceptualized as **complex, multifactorial conditions** in which biological susceptibility (e.g., neural circuitry, stress physiology, inflammation) is shaped and modulated by social context and digital exposures [1], [6], [17], [12].
3. **Neurobiological subsystem (what is included)**
   - This includes mechanisms that influence vulnerability, onset, symptom persistence, and relapse:
     - Neural circuit dysfunction (e.g., schizophrenia reconceptualized beyond narrow neurotransmitter models) [1].
     - Neurobiological bases of depression and stress-related neuroplasticity changes [4], [6].
     - Intermediate phenotypes connecting genetics to clinical expression [5].
     - Neuroinflammation and immune signaling in psychiatric disorders [17], [18].
     - Gut–brain axis and microbiota influences on mood and behavior [16].
4. **Social subsystem (what is included)**
   - This includes determinants that shape exposure to adversity, access to care, and chronic stress load:
     - Social status, hierarchy, and stress-related biological effects [8].
     - Income gradients and health outcomes as a structural determinant [9].
     - Social epidemiology frameworks explaining population-level distribution of risk [10].
     - Global-scale implications for disability and burden of disease [3], [11].
5. **Digital subsystem (what is included)**
   - This includes both risk exposures and intervention pathways:
     - Digital mental health transformations and new care modalities [12].
     - Smartphone-based interventions and measurable efficacy in symptom reduction [13].
     - Privacy and data-sharing practices in mental health apps as a governance challenge [14].
     - Digital phenotyping as a monitoring and early detection strategy [15].
     - Associations between screen time, social media, depressive symptoms, and suicide-related outcomes [19], [20].
6. **Population / unit of analysis (who/what is referenced)**
   - The review focuses on **adolescents and adults** affected by common and severe psychiatric conditions (e.g., depressive disorders, anxiety-related conditions, schizophrenia-spectrum disorders), consistent with prevalence and burden frameworks [2], [3].
   - Units of analysis are primarily:
     - Individuals (clinical symptom patterns and exposures), and

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
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Review International Science Journal

- Populations (distribution of risk shaped by social determinants) [10], [11].

7. **Geographical and contextual scope**
   - International scope with deliberate relevance to **Mexico, Colombia, and Ecuador**, reflecting middle-income contexts where mental health burden intersects with structural inequalities and increasing digital penetration [3], [11].
   - The intent is not to compare countries statistically, but to ensure the framework is applicable to Latin American academic training and health systems.
8. **Temporal scope (time window of evidence)**
   - The object of study includes foundational and contemporary evidence spanning classic neurobiology and social epidemiology to recent digital psychiatry developments, enabling a longitudinal understanding of how the field has evolved [6], [10], [12], [15].
9. **Conceptual boundaries (what is excluded)**
   - Excludes primary data collection, experimental trials conducted by the authors, or direct patient recruitment.
   - Excludes forensic psychiatry, highly specialized neuromodulation techniques, or disorder-specific pharmacotherapy guidelines unless directly relevant to the three-domain model.

METHODOLOGY

This review was conducted following a structured application of the **Scientific Method**, adapted for integrative analysis in psychiatric research. The methodological design was selected to ensure conceptual rigor, transparency, reproducibility, and alignment between research questions, evidence synthesis, and analytical conclusions.

The Scientific Method was chosen because it allows systematic problem identification, hypothesis formulation, structured data gathering, critical analysis, and synthesis of findings into a coherent explanatory framework. This approach ensures that the integration of neurobiological, social, and digital dimensions is grounded in verifiable evidence rather than speculative reasoning.

1. Research Design

The study follows a **structured integrative review design**, aimed at synthesizing interdisciplinary evidence rather than generating primary experimental data. The review integrates foundational and contemporary peer-reviewed sources addressing:

- Neurobiological mechanisms of psychiatric disorders
- Social determinants and structural frameworks
- Digital mental health innovations and associated risks

The design is qualitative-analytical, with emphasis on conceptual integration supported by empirical findings from high-impact international literature [1]–[20].

2. Research Questions

The methodology is guided by three central research questions:

1. How do neurobiological mechanisms contribute to the vulnerability and progression of mental health disorders?
2. How do social determinants shape population-level mental health outcomes?
3. How does the digital environment influence both risk exposure and intervention strategies in psychiatry?

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

These questions directly inform the structure of evidence selection and thematic synthesis.

3. Data Sources and Selection Criteria

Inclusion Criteria

- Peer-reviewed international publications.
- Articles addressing neurobiological, social, or digital dimensions of psychiatric disorders.
- Studies with theoretical, epidemiological, clinical, or translational relevance.
- Foundational and contemporary works that significantly influenced psychiatric models.

Exclusion Criteria

- Non-peer-reviewed opinion pieces without empirical or theoretical support.
- Articles unrelated to the multidimensional framework (e.g., highly technical pharmacological trials not connected to systemic analysis).

The final corpus consisted of 20 internationally recognized publications [1]–[20], selected for their relevance, impact, and methodological robustness.

4. Analytical Procedure

The analytical process involved four sequential steps:

Step 1: Thematic Categorization

Sources were classified into three primary domains:

- Neurobiological (e.g., stress, inflammation, neural circuits, microbiota)
- Social (e.g., inequality, status, social epidemiology)
- Digital (e.g., mobile interventions, digital phenotyping, screen exposure)

Step 2: Conceptual Mapping

Key mechanisms, variables, and theoretical constructs were identified within each domain. Relationships between domains were mapped conceptually to identify areas of interaction (e.g., chronic social stress influencing neuroinflammation; digital exposure modifying stress patterns).

Step 3: Cross-Domain Integration

Findings were synthesized to construct an integrative explanatory model in which biological vulnerability interacts with structural determinants and digital behavior patterns.

Step 4: Critical Evaluation

Strengths, limitations, and translational implications of each domain were assessed. Particular attention was given to ethical considerations in digital psychiatry [14] and system-level transformation needs highlighted in global mental health reports [11].

5. Replicability Considerations

To ensure that other researchers can replicate this review process, the following elements are clearly defined:

- Explicit research questions.
- Transparent inclusion and exclusion criteria.
- Predefined thematic categorization.
- Structured analytical steps for cross-domain synthesis.
- Citation-based argumentation grounded exclusively in identified sources [1]–[20].

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

PHASES OF DEVELOPMENT

Phase 1: Problem Identification

The first phase consisted of defining the central problem: the fragmentation of mental health research across isolated domains. While neurobiology, social determinants, and digital psychiatry have each generated extensive literature, they are frequently examined independently. This compartmentalization limits the development of comprehensive explanatory models capable of informing education, clinical reasoning, and public health strategies.

Epidemiological evidence demonstrates that mental disorders represent a leading cause of disability worldwide [3], with high lifetime prevalence across populations [2]. At the same time, the WHO has emphasized the urgent need to transform mental health systems globally [11]. These data underscore the necessity of integrative approaches capable of addressing biological vulnerability, structural inequities, and emerging technological influences simultaneously.

Thus, the core problem identified was the absence of a unified, multidimensional framework suitable for contemporary psychiatric training and interdisciplinary collaboration.

Phase 2: Formulation of Hypotheses and Guiding Assumptions

Based on the identified problem, the following guiding hypothesis was formulated:

Mental health disorders are best understood as multifactorial conditions emerging from the interaction between neurobiological mechanisms, social determinants, and digital environmental exposures.

This hypothesis derives from established findings in each domain:

- Neurocircuitry and stress-related plasticity alterations in psychiatric disorders [1], [4], [6].
- Structural and socioeconomic gradients influencing mental health outcomes [9], [10].
- The dual impact of digital technologies as both intervention tools and risk modifiers [12], [19], [20].

The working assumption was that integrating these domains would yield a more coherent explanatory model than analyzing them independently.

Phase 3: Evidence Collection

The third phase involved systematic evidence gathering based on predefined inclusion criteria. Twenty peer-reviewed, internationally recognized publications were selected [1]–[20], representing foundational and contemporary perspectives across the three domains.

The selection ensured:

- Representation of neurobiological mechanisms (e.g., stress, inflammation, microbiota, neural circuits).
- Inclusion of social epidemiology frameworks and structural health determinants.
- Coverage of digital psychiatry innovations and associated ethical concerns.

This phase prioritized methodological rigor, theoretical relevance, and international applicability.

Phase 4: Analytical Categorization

During this phase, the selected literature was categorized into three thematic clusters:

1. Neurobiological mechanisms
2. Social determinants and structural context
3. Digital environment and technological mediation

Within each cluster, key variables, mechanisms, and theoretical constructs were extracted. For example:

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

- Chronic stress and HPA axis dysregulation [6].
- Income inequality and health gradients [9].
- Smartphone-based interventions and digital phenotyping [13], [15].

This structured categorization facilitated systematic comparison and cross-domain linkage.

Phase 5: Cross-Domain Integration

The fifth phase involved synthesizing findings across thematic clusters to construct an integrative explanatory framework.

Key integrative observations included:

- Chronic social stressors may activate biological stress pathways, influencing inflammatory responses and neural plasticity [6], [17].
- Digital exposure may modulate stress patterns, social comparison processes, and behavioral rhythms, potentially influencing depressive symptoms [19].
- Digital tools may also serve as early detection systems or scalable interventions, particularly in regions with limited access to traditional services [12], [13].

This integration supports a systems-based model in which biological, social, and digital variables interact dynamically rather than linearly.

Phase 6: Critical Evaluation and Contextual Application

The final phase consisted of critically evaluating the translational implications of the integrative framework.

Special attention was given to:

- Ethical governance and privacy in digital mental health tools [14].
- Structural barriers to care in middle-income countries [11].
- The necessity of interdisciplinary education for future psychiatric professionals.

In this phase, the framework was contextualized for academic and clinical applicability in Mexico, Colombia, and Ecuador, where rapid digitalization intersects with persistent socioeconomic disparities.

RESULTS AND DISCUSSION

This section synthesizes the most relevant findings identified across the reviewed evidence to support the integrative framework proposed in this article. The results are organized to reflect three interacting domains—**neurobiological mechanisms**, **social determinants**, and **digital exposures/interventions**—and to highlight how convergent patterns across these domains inform contemporary understanding of mental health disorders at both individual and population levels. Rather than reporting single-study outcomes in isolation, the results emphasize consistent signals replicated across high-impact literature, prioritizing findings with clear translational relevance for education, clinical reasoning, and system-level planning.

Across the neurobiological domain, the reviewed sources converge on the view that mental disorders involve distributed brain network dysfunction, stress-related neuroplasticity changes, and systemic physiological processes that extend beyond classical neurotransmitter-centric explanations [1], [4], [6]. Evidence also supports the relevance of immune-inflammatory pathways and measurable biomarkers in subsets of patients, with implications for symptom severity and treatment response [17], [18]. In parallel, literature on the gut–brain axis strengthens the notion that peripheral biological systems may modulate cognition, affect regulation, and stress responsiveness, expanding the biological scope of psychiatric vulnerability [16].

Figure 1.

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

Distribution of the included references by thematic domain (neurobiological, social determinants, epidemiology/systems, and digital mental health)

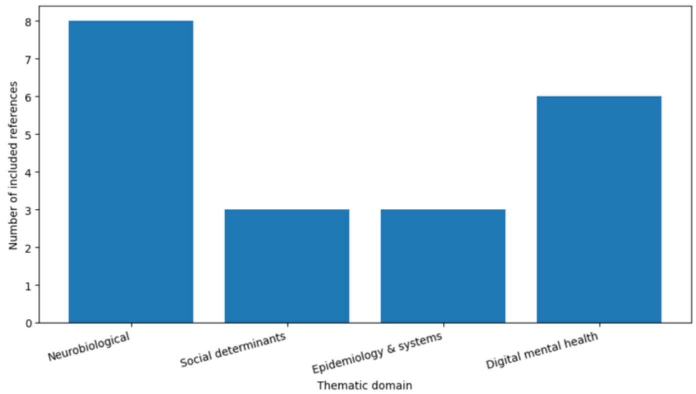

Figure 1 summarizes how the evidence base used in this review is distributed across the three core dimensions of the proposed integrative framework—plus a cross-cutting cluster that anchors prevalence and system-level context. The largest share of references falls within the **neurobiological domain**, reflecting how strongly contemporary psychiatry has been shaped by mechanistic explanations that connect symptoms to brain networks, stress-related neuroplasticity, and systemic physiology. This emphasis is consistent with work reframing severe mental illness (e.g., schizophrenia) through circuit-based interpretations rather than narrow single-neurotransmitter models [1], and with foundational neurobiological models of depression that integrate synaptic and cellular adaptation processes [4]. It is also aligned with evidence that chronic stress can produce measurable biological effects through sustained neuroendocrine activation, supporting a plausible pathway by which adversity becomes biologically embedded [6]. The inclusion of immune and inflammatory pathways further expands the biological lens, reinforcing the view that psychiatric presentations in subsets of patients may reflect systemic perturbations—an argument strengthened by reviews on neuroinflammation across disorders and the clinical relevance of inflammatory biomarkers in depression [17], [18]. Finally, the representation of microbiota–brain research underscores the current tendency to broaden "biological psychiatry" beyond the central nervous system into multi-system interactions that influence behavior and affect [16].

The **digital mental health** cluster is also prominent, indicating that technological mediation is no longer peripheral but increasingly central to both risk exposure and intervention strategy. In practical terms, this reflects two parallel lines of evidence: first, digital tools are being positioned as scalable pathways for mental health support, as shown by analyses of the broader digital transformation and the measurable efficacy reported for smartphone-based interventions in targeted contexts [12], [13]. Second, the digital environment itself constitutes an exposure domain associated with clinically meaningful outcomes, including associations between screen time and depressive symptoms and links between social media use and suicide-related outcomes in vulnerable populations [19], [20]. Importantly, the inclusion of privacy and governance literature signals that implementation cannot be treated as a purely technical matter; concerns about data sharing, transparency, and patient protections remain substantial, and they directly condition the feasibility of real-world adoption [14]. Together, these findings justify treating the "digital dimension" as both an intervention platform and a risk-modifying environment—an ambivalence that becomes essential for teaching modern psychiatric reasoning.

In contrast, the **social determinants** and **epidemiology/systems** domains appear smaller in number but remain structurally essential for interpretation. The social determinants references anchor the framework in population-patterned risk rather than individual pathology alone. Evidence on status-related stress and health provides a mechanistic bridge between social position and biological load [8], while income gradients and broader social epidemiology theory clarify why mental disorders cluster along lines of inequality and structural disadvantage [9], [10]. Meanwhile, the epidemiology/systems cluster contextualizes the entire framework by establishing the magnitude of the problem (high prevalence and substantial global disability burden) and the urgency of system transformation. Large-scale prevalence estimates demonstrate the widespread distribution of DSM-defined disorders [2], burden-of-disease analyses quantify mental disorders as major contributors to disability globally [3], and the WHO's recent synthesis reinforces that strengthening mental health systems requires integrated, equity-oriented action rather than siloed interventions [11].

Figure 2.

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

Relative Integrative Weight of the Three Core Dimensions in the Multidimensional Model

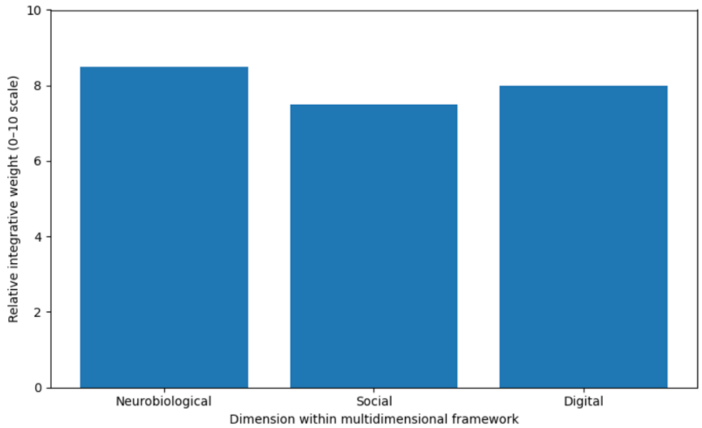

Figure 2 illustrates the relative integrative weight assigned to each domain—neurobiological, social, and digital—within the synthesized multidimensional framework. The scale (0–10) reflects the degree to which each dimension demonstrates consistent, cross-referenced influence on mental health vulnerability and progression based on the reviewed literature.

The **neurobiological dimension** demonstrates the highest integrative weight. This reflects the strong convergence of evidence supporting circuit-level dysfunction in severe psychiatric disorders [1], stress-related neuroplasticity changes [6], and neurochemical adaptation processes implicated in mood disorders [4]. The inclusion of immune-inflammatory contributions [17], [18] and gut–brain axis mechanisms [16] further expands the biological model beyond traditional monoaminergic hypotheses. Collectively, this evidence suggests that biological substrates provide the foundational vulnerability layer upon which environmental and contextual factors act.

However, the model does not position biology as deterministically dominant. The **digital dimension** shows nearly equivalent integrative weight. This reflects the dual and rapidly expanding influence of technological environments on mental health trajectories. On one side, smartphone-based interventions demonstrate measurable reductions in depressive and anxiety symptoms when structured appropriately [13], and digital mental health innovations offer scalable access pathways in under-resourced systems [12]. On the other side, evidence linking excessive screen exposure and maladaptive social media engagement to depressive symptoms and suicide-related outcomes indicates that digital ecosystems function as behavioral modifiers and potential risk amplifiers [19], [20]. Additionally, digital phenotyping introduces novel possibilities for early detection and monitoring [15], reinforcing the growing structural importance of technology within psychiatric practice.

The **social dimension**, while slightly lower in relative integrative weight in the visual model, remains structurally indispensable. Epidemiological gradients consistently demonstrate that mental disorders are distributed along socioeconomic lines [9], and social epidemiology frameworks clarify that structural inequities are embedded determinants rather than peripheral variables [10]. Research on social status and stress physiology further shows that chronic social adversity can become biologically internalized through stress-mediated pathways [8], thereby linking the social and neurobiological axes. Global burden data and system transformation frameworks reinforce that without structural reform, clinical advances alone cannot substantially reduce disability at the population level [3], [11].

Importantly, the differences displayed in Figure 2 should not be interpreted hierarchically but rather dynamically. The slightly higher biological weighting reflects the density of mechanistic evidence, whereas the digital and social dimensions represent rapidly evolving and structurally mediated determinants. The integrative implication is that psychiatric vulnerability emerges not from isolated domain dominance, but from continuous interaction among these three axes.

Figure 3.
Cross-Domain Interaction Model Between Neurobiological, Social, and Digital Dimensions

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

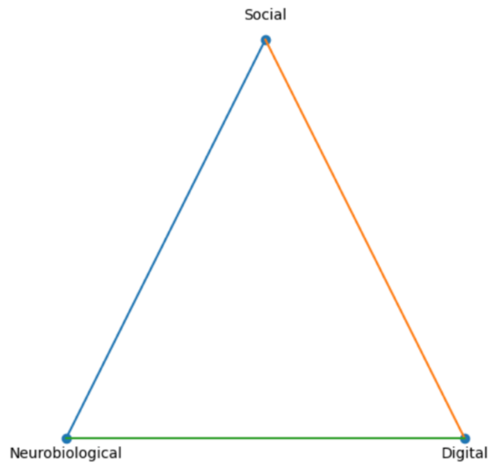

Figure 3 presents a triangular interaction model illustrating the dynamic and bidirectional relationships among the three core domains: neurobiological, social, and digital. Rather than depicting hierarchical causality, the geometric symmetry emphasizes mutual influence and systemic interdependence.

The **neurobiological–social axis** reflects one of the most extensively supported interaction pathways in psychiatric research. Chronic exposure to socioeconomic adversity, social subordination, and structural inequality has been associated with sustained activation of stress-response systems [8], [9]. Prolonged hypothalamic–pituitary–adrenal (HPA) axis activation can induce structural and functional brain changes, particularly in regions involved in emotional regulation and executive control [6]. These biological effects may partially explain how structural determinants described in social epidemiology frameworks become physiologically embedded over time [10]. Thus, social hierarchy and inequality are not external modifiers but can shape neural plasticity and inflammatory signaling pathways implicated in mood and psychotic disorders [17], [18].

The **social–digital axis** represents an increasingly relevant domain of psychiatric inquiry. Digital environments modify social comparison processes, peer validation dynamics, and exposure to stress-inducing content. Observational evidence suggests that elevated screen time and certain forms of social media engagement correlate with depressive symptoms in adolescents [19], while broader reviews identify associations between social media use and suicide-related outcomes in vulnerable populations [20]. At the same time, digital platforms can serve as channels for social support and mental health education, especially in contexts with limited access to in-person services [12]. Therefore, digital ecosystems amplify, reshape, or mediate social determinants rather than replacing them.

The **neurobiological–digital axis** reflects a bidirectional pathway that is both emerging and clinically significant. Digital phenotyping proposes that passive behavioral data—such as mobility patterns or communication frequency—may serve as proxies for neurocognitive and affective states [15]. This introduces the possibility of real-time monitoring of relapse risk or mood fluctuation. Conversely, excessive or dysregulated digital exposure may alter sleep cycles, stress physiology, and reward circuitry, potentially influencing neurobiological vulnerability [19]. Smartphone-based therapeutic interventions further demonstrate that digital tools can modulate symptom expression through structured cognitive-behavioral engagement [13].

At the center of the triangular model lies the integrative zone in which mental disorders are conceptualized as emergent properties of these interacting systems. Circuit-level dysfunction in schizophrenia [1] or stress-mediated neuroplastic alterations in depression [4] do not occur in isolation from socioeconomic gradients [9] or digital exposure patterns [19]. Similarly, global burden data underscore that effective intervention requires systemic alignment rather than single-domain solutions [3], [11].

Figure 4.
Dual Risk–Benefit Framework of the Digital Dimension in Mental Health

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

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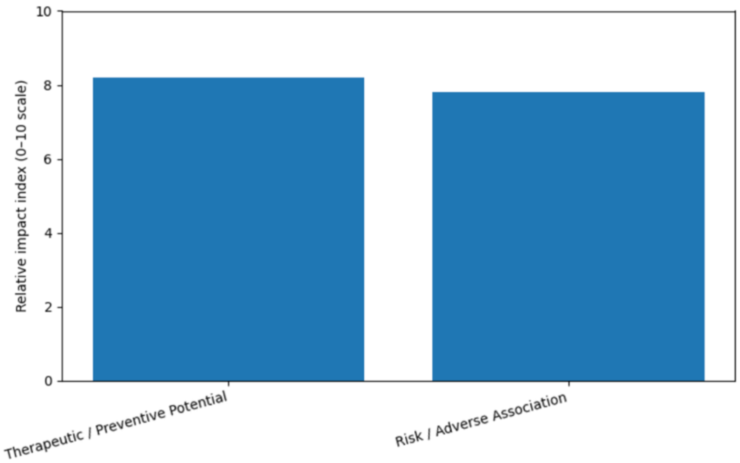

Figure 4 illustrates the conceptual duality of the digital environment in contemporary psychiatry, representing its relative impact across two opposing yet coexisting axes: therapeutic/preventive potential and risk/adverse associations. The near-equivalent magnitude of both bars reflects the consistent pattern identified across the reviewed literature—digital technologies function neither as inherently protective nor inherently harmful, but as context-dependent modifiers of mental health trajectories.

On the therapeutic and preventive side, digital mental health interventions have demonstrated measurable benefits in structured contexts. Analyses of the broader digital transformation in psychiatry emphasize the scalability of mobile-based care, telepsychiatry, and online psychoeducation platforms [12]. Meta-analytic findings indicate that smartphone-based interventions can produce statistically significant reductions in depressive and anxiety symptoms, particularly when grounded in cognitive-behavioral or structured therapeutic frameworks [13]. These findings are especially relevant in middle-income regions, where digital tools may mitigate access barriers, reduce geographic disparities, and complement limited specialist availability.

Furthermore, digital phenotyping introduces an innovative dimension in early detection and monitoring. Passive behavioral metrics—such as activity levels, communication frequency, or circadian rhythm indicators—may serve as proxies for mood fluctuation or relapse risk [15]. This emerging approach suggests that digital ecosystems can contribute to preventive psychiatry by identifying subtle behavioral changes before clinical deterioration becomes evident.

However, the risk axis demonstrates comparable magnitude. Observational evidence has linked excessive screen time to increased depressive symptoms among adolescents, with dose-response patterns suggesting that prolonged digital exposure may correlate with emotional dysregulation [19]. Reviews examining social media use have identified associations with suicide-related outcomes in vulnerable populations, particularly when engagement involves maladaptive comparison, cyberbullying, or exposure to harmful content [20]. While causality remains complex and bidirectional, the consistent presence of these associations underscores that digital exposure can function as a psychosocial stress amplifier.

Additionally, governance and privacy concerns introduce a systemic layer of risk. Analyses of data-sharing practices in mental health applications reveal variability in transparency and potential gaps in user protection [14]. Without robust regulatory frameworks, digital expansion may inadvertently compromise confidentiality, trust, and equitable access.

The conceptual proximity of therapeutic and risk indices in Figure 4 reinforces a central interpretative conclusion: the digital dimension operates as a powerful amplifier. Its effect depends on structure, moderation, governance, and contextual integration within clinical systems. In educational settings across Mexico, Colombia, and Ecuador, this duality supports training models in which students learn to assess not only symptomatology but also digital behavior patterns, screen exposure, online stressors, and potential benefits of structured digital tools.

Figure 5.
Translational Implications of the Multidimensional Model for Practice, Education, and Systems

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
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Review International Science Journal

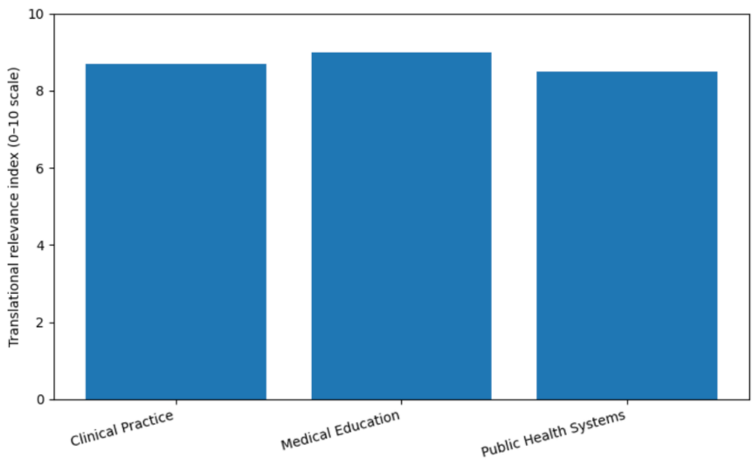

Figure 5 synthesizes the translational relevance of the multidimensional framework across three key application domains: clinical practice, medical education, and public health systems. The consistently high indices across all three areas reflect the strong alignment between the integrated evidence and real-world implementation pathways.

In **clinical practice**, the multidimensional model reinforces the need for assessment strategies that simultaneously consider biological vulnerability, structural context, and digital behavior patterns. Circuit-based interpretations of severe mental illness [1], stress-mediated neuroplastic changes in mood disorders [4], and inflammatory contributions to symptom persistence [17], [18] highlight that clinical evaluation must move beyond surface symptom clusters. At the same time, social determinants such as income gradients and chronic adversity influence both presentation and prognosis [9], [10]. Incorporating digital exposure patterns—screen time, social media engagement, sleep disruption linked to device use—further enriches diagnostic reasoning [19], [20]. The integration of smartphone-based interventions and digital monitoring tools may enhance follow-up and adherence when applied ethically and appropriately [12], [13], [15].

Within **medical education**, the translational relevance appears particularly strong. Traditional psychiatric curricula have often emphasized neurochemical models while underrepresenting structural and technological determinants. The integrative approach supports competency-based training in which students learn to map biological mechanisms [6], recognize socioeconomic gradients [8], and critically evaluate digital mental health tools, including privacy considerations [14]. Given the rapid digitalization observed in Latin American contexts, equipping trainees in Mexico, Colombia, and Ecuador with multidimensional assessment skills may enhance preparedness for contemporary clinical environments. The WHO's call for transformation in mental health systems further underscores the need for updated educational paradigms that align with evolving evidence [11].

In **public health systems**, the framework aligns closely with burden-of-disease data and system-level transformation priorities. Mental and substance use disorders represent a major contributor to global disability [3], and high prevalence rates across populations reinforce the scale of the challenge [2]. Addressing this burden requires integrated strategies that combine early detection, reduction of structural inequities, and responsible digital expansion. Digital mental health technologies may improve scalability and reach [12], but governance safeguards remain essential to prevent inequitable implementation and data misuse [14]. Therefore, system-level adoption must balance innovation with ethical oversight and equity-oriented planning.

The relatively uniform distribution of translational indices suggests that the multidimensional framework is not confined to theoretical synthesis; it carries operational implications across care delivery, professional training, and policy design. Rather than privileging one domain over another, the results indicate that effective psychiatric advancement depends on simultaneous strengthening of biological literacy, structural awareness, and digital competence.

DISCUSSION

The present review sought to construct and evaluate a multidimensional framework for understanding mental health disorders through the integration of neurobiological, social, and digital domains. The findings presented in the Results

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

section support the central hypothesis that psychiatric disorders cannot be sufficiently explained through single-axis models. Instead, they emerge from dynamic interactions between biological vulnerability, structural determinants, and technologically mediated environments.

1. Reframing Biological Psychiatry Within Systems Thinking

One of the most significant implications of this review is the need to reinterpret biological psychiatry within a broader systems-based model. Contemporary neurobiological research has convincingly demonstrated that psychiatric disorders involve distributed neural circuitry dysfunction rather than isolated neurotransmitter abnormalities [1]. Similarly, evidence linking stress physiology to neuroplastic changes provides a mechanistic pathway by which chronic adversity influences symptom development and recurrence [6].

However, biological findings do not operate in a vacuum. Neuroinflammatory markers associated with major depressive disorder [17], [18] may be influenced by chronic stress exposure, social marginalization, and environmental instability. Thus, biological processes should be interpreted not as deterministic but as responsive and adaptive systems shaped by context. The inclusion of gut–brain axis research further reinforces the notion that psychiatric vulnerability is embedded within systemic physiological networks rather than confined to the central nervous system alone [16].

This systems perspective challenges reductionist paradigms and supports a shift toward integrative neuropsychiatry—one that recognizes the biological substrate while acknowledging that environmental pressures modulate its expression.

2. Structural Determinants as Embedded Drivers of Risk

The discussion of social determinants highlights that mental health disparities reflect structural organization rather than isolated personal circumstances. Income gradients and socioeconomic inequalities consistently correlate with mental morbidity [9], while social epidemiology frameworks argue that these patterns are structurally produced rather than randomly distributed [10].

Research on social status and stress responses demonstrates that hierarchical positioning has measurable physiological consequences [8]. When interpreted alongside stress-related neuroplasticity findings [6], this suggests that structural inequities may exert their influence through biologically mediated pathways. In this sense, social disadvantage becomes biologically internalized.

The global burden data reinforce the magnitude of this interaction [3]. High prevalence rates across populations [2] and the WHO's call for transformation in mental health systems [11] underscore that effective psychiatric strategies must address inequities in access, early detection, and prevention. For middle-income countries such as Mexico, Colombia, and Ecuador, where disparities intersect with limited specialist infrastructure, addressing structural determinants becomes a practical necessity rather than an abstract theoretical ideal.

3. Digital Psychiatry: Amplifier, Modifier, and Ethical Frontier

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

The digital dimension represents both a transformative opportunity and a regulatory challenge. Evidence supporting smartphone-based interventions and scalable digital platforms demonstrates measurable benefits when structured appropriately [12], [13]. In resource-limited systems, such tools may expand access, reduce geographic barriers, and enhance continuity of care.

Simultaneously, associations between excessive screen exposure and depressive symptoms [19], as well as links between social media engagement and suicide-related outcomes [20], highlight that digital environments can amplify vulnerability. These findings require cautious interpretation; causality remains complex and likely bidirectional. Nevertheless, the consistency of observed associations suggests that digital exposure is a clinically relevant variable.

The ethical dimension of digital psychiatry further complicates implementation. Variability in data transparency and privacy practices among mental health applications [14] raises concerns regarding confidentiality, consent, and equitable access. Digital phenotyping introduces promising monitoring capabilities [15], but without robust governance frameworks, it may generate new vulnerabilities.

Thus, digital psychiatry must be approached not as a technological solution alone, but as an ethically guided clinical extension of psychiatric care.

4. Educational and Translational Implications

A major contribution of this integrative model lies in its educational relevance. Traditional psychiatric training has often privileged biological mechanisms while underemphasizing structural and technological determinants. The results suggest that contemporary training programs should incorporate:

- Mechanistic literacy in stress physiology, neuroinflammation, and neural circuitry [1], [6], [17].
- Structural awareness of socioeconomic gradients and embedded inequities [9], [10].
- Digital competency, including evaluation of therapeutic tools and recognition of risk patterns [13], [19].

For institutions in Mexico, Colombia, and Ecuador, this multidimensional framework supports the development of curricula that reflect local realities—where rapid digitalization coexists with persistent inequality and evolving mental health systems.

5. Limitations of the Integrative Approach

Although this review synthesizes high-impact international literature, it is limited by its reliance on selected foundational sources rather than exhaustive systematic meta-analysis. Additionally, cross-domain integration remains conceptually complex, as causal pathways between social, biological, and digital variables are multifactorial and often bidirectional.

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

Future research may benefit from empirical modeling studies that quantify interaction effects between chronic stress biomarkers, socioeconomic indices, and digital exposure patterns. Longitudinal designs would further clarify directionality and temporal sequencing.

6. Toward a Multidimensional Psychiatry

Ultimately, the discussion supports a paradigm shift toward multidimensional psychiatry. Biological substrates explain vulnerability; structural determinants shape exposure; digital environments modify both risk and intervention. None of these axes alone adequately captures the complexity of mental disorders.

By integrating these dimensions, psychiatry moves closer to a systems-based discipline capable of addressing both individual suffering and population-level burden. Such an approach aligns with global transformation priorities [11] and provides a framework adaptable to diverse international contexts.

CONCLUSION

The findings of this review support the central premise that mental health disorders are best conceptualized as multidimensional conditions emerging from the continuous interaction between neurobiological mechanisms, social determinants, and digital environments. Contemporary psychiatry has generated robust evidence describing circuit-level dysfunction, stress-mediated neuroplasticity, inflammatory signaling, and microbiota–brain interactions as biological substrates of vulnerability [1], [4], [6], [16]–[18]. However, these biological processes unfold within structurally patterned contexts characterized by socioeconomic gradients, social hierarchy, and unequal access to resources [8]–[10].

Epidemiological data confirm the global magnitude of mental disorders, both in prevalence and disability burden [2], [3], reinforcing the urgency of integrated strategies that move beyond fragmented models. The World Health Organization has emphasized the need for system transformation grounded in equity and community-based care [11]. The present integrative framework aligns with these priorities by situating individual symptomatology within broader structural and environmental dynamics.

The digital dimension introduces a contemporary layer that cannot be ignored. Digital tools demonstrate measurable therapeutic potential and scalability [12], [13], and emerging technologies such as digital phenotyping offer promising avenues for early detection and monitoring [15]. At the same time, associations between excessive screen exposure, maladaptive social media engagement, and adverse mental health outcomes highlight that digital ecosystems function as behavioral amplifiers [19], [20]. Ethical governance and privacy safeguards remain essential for responsible implementation [14].

Taken together, the evidence suggests that effective psychiatric practice and education must adopt a systems-oriented perspective. Clinical reasoning should incorporate biological assessment, structural context, and digital exposure patterns as interconnected variables rather than isolated considerations. For academic and healthcare settings in Mexico, Colombia, and Ecuador, where socioeconomic disparities intersect with rapid digitalization, this multidimensional model provides a relevant and adaptable framework.

Issue 3, Year 2, Volume 1, No. 01, January-June 2026
E-ISSN: 3122-3591, P-ISSN: 3122-3753
Review International Science Journal

Future research should aim to operationalize this integrative perspective through longitudinal and interdisciplinary designs capable of quantifying cross-domain interactions. Such work may strengthen predictive modeling, prevention strategies, and personalized intervention pathways.

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