What are the relationships between the Immune System, Neurodevelopmental and Psychiatric Disorders and Cancer?

Overview

Across these papers, the immune system acts as a shared biological thread linking **neurodevelopmental disorders, psychiatric illnesses, and cancer**. Immune molecules and cells shape brain development and function, and their dysregulation can drive both disordered neurodevelopment/behavior and tumor biology.

Immune System and Neurodevelopmental Disorders

- Immune processes (microglia, Toll-like receptors, cytokines, inflammasomes) are **critical for normal brain development** (neurogenesis, synaptic pruning, circuit formation) (Zengeler & Lukens, 2021; Wang et al., 2025).
- Disrupted innate immune signaling is functionally linked to NDDs such as **autism and schizophrenia** (Zengeler & Lukens, 2021; Wang et al., 2025).
- Maternal immune activation (infection, autoimmune disease, obesity, asthma, stress) during pregnancy increases risk of NDDs (ASD, ADHD, Tourette) via inflammatory signals and epigenetic "priming" of offspring brain/immune cells (Gagliano et al., 2025; Kim et al., 2024; Han et al., 2021; Solek et al., 2018; Hassamal, 2023).
- Children with ASD/ADHD/IDD show shared immune signatures (altered cytokines, IL-1 signaling, Th1 polarization, impaired compensatory anti-inflammatory responses) (Sreenivas et al., 2023; Gagliano et al., 2025; Gibney & Drexhage, 2013; Wang et al., 2025; Han et al., 2025).

Examples of Immune–NDD Links

Feature	Immune aspect	Disorders	Citations
Maternal infection / autoimmune disease	Maternal immune activation, cytokines	ASD, schizophrenia, ADHD, Tourette	(Gagliano et al., 2025; Kim et al., 2024; Han et al., 2021; Solek et al., 2018; Wang et al., 2025)
Child immune profile	Altered cytokines, CIRS depletion	ASD, ADHD, IDD	(Sreenivas et al., 2023; Gibney & Drexhage, 2013)
Co-occurring immune disease	Autoimmune/allergic disorders in families	Broad NDD & youth psychiatric risk	(Gagliano et al., 2025; Wang et al., 2025)

FIGURE 1 Illustrative immune mechanisms linked to neurodevelopmental disorders.

Immune System and Psychiatric Disorders

- Reviews describe **immune dysregulation** (altered cytokine profiles, microglial activation, gut–brain immune changes) in **depression, schizophrenia, bipolar disorder, PTSD, and ASD** (Novellino et al., 2020; Pape et al., 2019; Gibney & Drexhage, 2013; Upthegrove et al., 2025; Jiao et al., 2025; Nusslock et al., 2024; Kokkosis & Tsirka, 2020).
- Inflammation and cytokines (e.g., IL-6, IL-1β, TNF-α, IL-17) can modulate brain circuits controlling threat, reward, and mood, contributing to depression and related conditions (Upthegrove et al., 2025; Nusslock et al., 2024; Lu et al., 2023; Hassamal, 2023; Novellino et al., 2020; Capuron & Miller, 2011).
- Chronic stress co-activates stress circuits and inflammatory pathways, creating a feed-forward loop of **neuroinflammation and depressive symptoms** (Kokkosis & Tsirka, 2020; Hassamal, 2023; Nusslock et al., 2024).

Immune System, Cancer, and Neuro-psychiatric Conditions

- Cancer is tightly connected to immunity and inflammation; many tumors are shaped by immune surveillance and inflammatory microenvironments (Nussinov et al., 2022; Novellino et al., 2020).
- The same immune pathways and signaling molecules (TLRs, cytokines, small GTPases, MAPK pathways) operate in **NDDs, psychiatric illness, and cancer**, with timing, cell type, and chromatin context determining whether the outcome is disordered development, altered behavior, or uncontrolled proliferation (Nussinov et al., 2022; Novellino et al., 2020; Gibney & Drexhage, 2013; Zengeler & Lukens, 2021; Robinson-Agramonte et al., 2022; Lu et al., 2023).
- Some cancers and cancer immunotherapies can themselves provoke **psychiatric symptoms** (e.g., interferon-α–induced depression, paraneoplastic limbic encephalitis with mood and cognitive changes), again implicating inflammatory and autoantibody-mediated mechanisms (Novellino et al., 2020).

Conceptual “Triangle”: Immunity–Brain–Cancer

- One synthesis proposes immunity as a **common connector**: the immune and nervous systems co-evolve; immune signals sculpt the developing brain, and dysregulated signaling in specific cells and windows can lead to **NDDs**, while later-life somatic mutations in the same pathways favor **cancer** (Nussinov et al., 2022).
- Brain transcriptomic and epigenetic studies in NDDs show **dysregulated immune pathways and shared genes between immune regulation and synapse biology**, supporting a genetic/epigenetic bridge (Gagliano et al., 2025; Wang et al., 2025; Han et al., 2025; Han et al., 2021).
- The emerging field of **immunoneuropsychiatry** emphasizes that subsets of neurodevelopmental and psychiatric disorders are best understood as **immune-mediated brain disorders**, overlapping conceptually with cancer immunology (Pape et al., 2019; Gagliano et al., 2025; Gibney & Drexhage, 2013; Nusslock et al., 2024).

Conclusion

Immune mechanisms are deeply intertwined with brain development, psychiatric function, and cancer biology. Shared pathways—especially innate immune signaling, cytokines, microglia, and epigenetic regulation—form a common framework in which early or chronic immune perturbations can manifest as neurodevelopmental disorders, psychiatric illness, cancer, or combinations of these, depending on timing, genetic background, and tissue context.

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