Parenthood: The Keystone. The Parental Brain, Development, and Salutogenesis Parental Functioning as the Conductor of Adult Health Outcomes

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***Abstract**: The transition to parenthood has undergone a radical structural and conceptual evolution in recent decades, driven by unprecedented demographic shifts and rapidly changing family paradigms. These societal changes are profoundly reshaping the psychological and clinical framework of parenthood. Concurrently, discoveries in cognitive neuroscience and psychoneuroendocrinoimmunology (PNEI) have revealed that this transition represents a unique biological window, characterized by extraordinary adult neuroplasticity and epigenetic vulnerability. Neuroimaging studies confirm that entering parenthood triggers extensive anatomical remodeling in both biological and non-biological (or non-gestational) parents.*

However, this heightened neuroplasticity also renders the parental brain highly vulnerable to environmental and psychosocial stressors. Untreated parental distress compromises interactional synchrony and introduces severe transgenerational risks, predicting an increased susceptibility to emotional, behavioral, and even psychotic symptoms in the adult offspring. Furthermore, under the weight of modern socioeconomic pressures and unmitigated stress, parents face the risk of parental burnout.

Therefore, building a robust culture of health and well-being that is both equitable and sustainable requires an intersectoral and multidimensional framework where governmental *institu-*

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tions, healthcare systems, commercial enterprises, local communities, and individual citizens share a collective responsibility.

***Keywords**: Parenthood, matrescence, perinatal depression, parental burnout.*

Scenarios of Parenthood

The term parenthood (or parenting) defines a set of complex, continuously evolving functions and competencies. These pertain to an adult individual's capacity to protect, care for, and affectively and socially regulate – within a relationship – another individual who, due to their developmental stage or specific psychophysical conditions, requires the presence of a figure capable of recognizing and satisfying their needs (Venuti *et al.*, 2018).

In recent decades, the transition to parenthood has assumed distinct characteristics that have substantially altered its nature compared to the recent past. This new configuration is documented by the latest indicators from the National Institute of Statistics (Istat, 2026), which reveal that births in Italy stand at 355,000, marking a 3.9% decrease compared to 2024. The decline in fertility continues, dropping to 1.14 children per woman in 2025, while life expectancy remains high, reaching 81.7 years for men and 85.7 years for women in 2025. Couples with children constitute 28.4% of families, while those without children account for 20.2%. Concurrently, the average age at childbirth has risen to 32.7 years. Over the years, single-parent families have increased, now representing one in ten families; these are predominantly single mothers (8.6%), though cases of single fathers with children are also evident (2.2%).

Likewise, couples' expectations regarding the parental role have shifted; its boundaries are no longer as clearly demarcated and defined as they were in the traditional family, yielding to a fully shared parental responsibility. The pluralization of family forms and the emergence of new family identities have shifted the focus of research and clinical family assessment toward the study of coparenting, as well as paternal and maternal functions that transcend gender definitions. As highlighted in a previous article published in this journal (De Bari, Terni, 2023), research has repeatedly demonstrated that children who do not share a biological bond with their parents do not differ in adjustment from those who do. Similarly, no correlation emerges between parents' sexual orientation and any measure of the child's emotional, psychosocial, or behavioral adjustment. Across diverse family configurations, high levels of parental stress, interparental conflict, and an imbalance between affective and ethico-normative functions are what consistently predict long-term maladjustment in the offspring.

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Becoming Parents is a PNEI experience

The developmental window spanning from conception to the first 6,000 days of life is characterized by extraordinary neuroplasticity and heightened biological vulnerability, driven by intense epigenetic activity and the dynamic, bidirectional processes within the parent-child dyad. Investigating the psychoneuroendocrineimmunological (PNEI) complexity underlying the intersubjective and affective dynamics between parents and their offspring is of paramount importance for promoting long-term well-being and safeguarding health trajectories into adulthood.

During fetal life and the first two years postpartum – a critical phase of profound plasticity – epigenetic mechanisms are highly active. Environmental inputs during this period are capable of altering brain architecture, the composition of the infant's gut microbiota, and endocrine-metabolic and immunological programming, thereby exerting a lasting influence on the behavior of both the child and the future adult. Consequently, it is essential for parents and expectant parents to recognize that a nurturing and supportive environment acts as a primary driver of health promotion, whereas an adverse environment can serve as a factor of systemic vulnerability contributing to the pathogenesis of current or future chronic diseases (Carbonella, Gandini, 2023).

The transition to parenthood is a profound developmental journey marked by complex, interconnected changes that reshape nearly every aspect of a new parent's life. Recent neuroimaging research highlights that entering parenthood involves a remarkable degree of adult brain plasticity and physiological adaptation, demonstrating how these biological processes facilitate and support the highly complex cognitive and behavioral demands of caregiving (Servin-Barthet *et al.*, 2023) and emotional attunement with one's children (Carmona, Vilarroya, 2025).

Structural Brain Plasticity in Matrescence and Patrescence

During pregnancy and the postpartum period, significant neural plasticity occurs within both the structure and function of the adult brain, serving as an essential neurological adaptation for infant care. The "parental brain network" comprises interconnected structures critical for empathy, emotion regulation, executive functions, decision-making, threat assessment, motivation, and reward processing.

The structural and functional mapping of the human parental brain has only recently become a primary focus of cognitive neuroscience. The most robust neuroimaging findings to date concern the specific extent to which gray matter volumes undergo profound anatomical remodeling during pregnancy and the postpartum peri-

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od. Recent prospective studies (Pawluski, 2024) demonstrate that, from the preconception period to the early postpartum weeks, primiparous mothers undergo extensive reductions in gray matter volume – amounting to approximately 1% – localized predominantly within brain regions responsible for social cognition.

The brain structures most affected by pregnancy are those underlying the capacity to mentalize or to cognitively infer the needs of others (Theory of Mind, ToM), rendering these structural changes highly functional and fundamental for effective caregiving. These anatomical modifications are remarkably consistent, with 92% of mothers showing similar patterns of structural remodeling; furthermore, these volumetric reductions correlate strongly with circulating progesterone levels during the third trimester and can persist for several years postpartum (Hoekzema, 2022).

Recent data show that these reductions in gray matter volume accelerate during late pregnancy and can be significantly modulated by the mode of delivery in the immediate postpartum period. For instance, Paternina-Die *et al.* (2024) demonstrated that mothers who underwent a scheduled cesarean section (prior to the onset of spontaneous labor) exhibited a significantly greater increase in cortical volume, thickness, and surface area from pregnancy to the postpartum period compared to mothers who experienced spontaneous labor, independent of gestational age, maternal age, and other potential confounding variables. This clinical evidence suggests that the acute immune and endocrine processes triggered during active labor and delivery exert a direct modulating impact on maternal neurostructural adaptations.

During the early postpartum weeks and months, mothers exhibit a subsequent increase in gray matter volume within subcortical and cortical areas associated with reward, bonding, and ToM, such as the amygdala and the ventral striatum. Conversely, in first-time fathers, longitudinal neuroimaging assessments during pregnancy and the first years of parenthood reveal an approximate 1% reduction in gray matter volume within cortical networks responsible for visual processing, attentional allocation, and empathy.

Although the differential impact of multiple or subsequent pregnancies on these structural brain modifications remains to be fully elucidated in humans, longitudinal animal laboratory models suggest that parity history exerts a cumulative influence on the maternal brain. Straathof *et al.* (2026) conducted a prospective preconception cohort study involving 110 women, utilizing multimodal neuroimaging data to compare the effects of a second pregnancy versus first pregnancies and nulliparous controls. Their analysis evaluated changes in gray matter volume, resting-state functional connectivity, the microstructural organization of white matter tracts, and neuronal metabolite concentrations.

The results highlight distinct volumetric trajectories: both first and second

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pregnancies are associated with widespread reductions in cortical volume compared to nulliparous controls. However, this volumetric reduction is significantly more pronounced in primiparous women (3.1%) compared to multiparous women (2.8%). Furthermore, the common neurostructural alterations shared between the first and second pregnancies are localized primarily within the Default Mode Network (DMN), the frontoparietal network, and the ventral attention network. Crucially, the first pregnancy exhibits more extensive structural alterations across these specific networks, whereas the second pregnancy more selectively involves the somatomotor and dorsal attention networks.

The DMN plays a well-documented role in introspection, self-referential processes, and social cognition (Davey *et al.*, 2016). Together with the cuneus – the primary anatomical region where the differential effects of a first versus a second pregnancy on functional network coherence were observed – it represents the core neural architecture underlying the structural representation of the self. During the transition to parenthood, structural and functional remodeling within these neural networks drives profound modifications in maternal self-perception and enhances the mother's capacity to accurately interpret the physiological needs and emotional states of her offspring (Hoekzema *et al.*, 2022).

Regarding maternal behavior and mental health, Straathof *et al.* (2026) observe that in both first and subsequent pregnancies, these neurostructural adaptations are associated with peripartum depression and psychological distress, although they present distinct temporal profiles. In primiparous women, this correlation culminates during the postpartum period, whereas in multiparous women, it manifests predominantly during gestation. This longitudinal evidence underscores that both first and second pregnancies leave a unique and distinct imprint on the female brain, characterized by specific alterations in gray matter morphology, white matter tracts, and resting-state functional connectivity.

The first pregnancy induces a "primary adaptation" of the neural networks governing introspection, self-perception, and social cognition (DMN and frontoparietal cortex), which is subsequently refined and consolidated during the second pregnancy. Conversely, subsequent pregnancies appear to enhance the neuroplasticity of externally oriented networks, such as the somatomotor and attentional networks, likely to meet the increased behavioral and caregiving demands associated with managing multiple children. Although these pregnancy-induced neural alterations are partially reversible, selected structural modifications can persist for years after childbirth.

Matrescence (Carmona, 2019; 2025) constitutes a fundamental developmental transition encompassing the pre-conception period, pregnancy, childbirth, or alternative pathways to parenthood such as surrogacy and adoption, extending

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through the postnatal period and beyond (Raphael, 1975; Athan, 2024, 2025). This transition is experienced by 80-90% of women globally (Livingston, 2018).

A recent narrative review by Worska *et al.* (2026) synthesized current evidence on the profound hormonal and neuroplastic fluctuations characterizing the maternal brain during pregnancy and the postpartum period, critically evaluating their implications for cognitive function and mental health. The literature demonstrates a U-shaped trajectory in gray matter volume changes, alongside adaptive regional alterations within the hippocampus, amygdala, and prefrontal cortex. These neural dynamics are closely linked to the subjective phenomenon of "mommy brain" (momnesia), which is characterized by forgetfulness, distractibility, and decreased mental clarity. Chief among the contributing factors to this cognitive fog are sleep deprivation, the high mental load of household management, and the hypervigilance required for infant care. Furthermore, executive functions – including planning, cognitive flexibility, and inhibitory control – undergo remodeling secondary to structural changes in the prefrontal cortex.

In fathers, the investigation into structural brain plasticity is a rapidly expanding field (Abraham *et al.*, 2022). Emerging data indicate that during the transition to parenthood, the paternal brain undergoes an approximate 1% reduction in gray matter volume within cortical structures responsible for visual processing, attention, and empathy (Martinez-Garcia *et al.*, 2023). Longitudinal reductions in paternal gray matter volume during the first four months postpartum are positively associated with sensitive and synchronous caregiving behaviors. These changes specifically involve subcortical and cortical regions implicated in reward processes, bonding, and Theory of Mind (ToM), including the amygdala and striatum (Kim *et al.*, 2014).

Fathers who are more deeply engaged in direct childcare exhibit neural activation profiles that mirror maternal brain adaptations. This aligns with preclinical literature demonstrating that paternal neural modifications can be environmentally driven and flexibly activated by direct, prolonged exposure to offspring (Feldman, 2015). Finally, contemporary research indicates that the experience of transitioning to parenthood is associated with widespread reductions in gray matter volume across multiple brain areas in both gestational and non-gestational parents (Pawluski, 2024). While much remains to be elucidated regarding the structural plasticity of the parental brain, it is clear that pregnancy hormones are not the sole drivers of these neural changes; the behavioral experience of parenting itself plays a fundamental role.

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Perinatal Distress, Neurobiological Dysfunction, and Clinical Outcomes

Parent-infant interactions rely on tightly regulated patterns of behavioral activation and deactivation, dictated by the salience of infant cues and the caregiver's capacity to attune to the infant's emotional and physiological needs. This attunement enables parents to provide adaptive responses that are fundamental to infant survival and attachment security. Affective relationships activate emotional salience circuits through the involvement of the basolateral nuclei of the amygdala. By interacting with dopaminergic motivational pathways, this system enhances the salience of infant sensory signals, driving the adult toward proximity-seeking and caregiving behaviors.

The Salience Network (SN) is a core intrinsic connectivity network anchored in the anterior insula and the dorsal anterior cingulate cortex (dACC). At the subcortical level, it integrates the amygdala, hippocampus, ventral striatum, ventral tegmental area (VTA), hypothalamus, thalamus, and substantia nigra – structures collectively involved in nurturing behaviors and autonomic responses (Seeley, 2019). Dysregulated SN activity is linked to maladaptive behavioral phenotypes observed across various clinical conditions, including mood disorders, neurodegenerative diseases, autism, schizophrenia, epilepsy, insomnia, chronic pain, and post-traumatic stress disorder (PTSD).

In the parenting context, SN dysregulation disrupts the neural predictive coding of stimuli, compromising parental interoceptive processes and hindering the formation of a secure caregiver-infant bond (Schimmelpfennig *et al.*, 2023). This disruption, in turn, negatively impacts the trajectory and expression of cognitive development in the offspring (Cermakova *et al.*, 2023).

Parental stress – the physiological and psychological response to the ongoing demands of childcare – acts as a critical modulator of parenting-related brain remodeling (Rutherford, Mayes, 2019). Chronically elevated levels of perceived parental stress are strongly associated with perinatal depression, a burden faced by a significant percentage of parents during gestation and the postpartum period (Pawluski *et al.*, 2017).

The most common postpartum emotional disturbance is the "baby blues" which affects the majority of new mothers immediately after delivery. Characterized by transient mood lability, physical exhaustion, anxiety, and role uncertainty, the baby blues typically resolve spontaneously within two weeks. In contrast, clinical perinatal mental disorders exert lasting negative effects on parental health, caregiving dynamics, and child development (Stein *et al.*, 2014).

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During the postpartum period, high maternal stress is linked to reduced functional activity in areas responsible for decision-making and emotion regulation, such as the orbitofrontal gyrus and the amygdala. Specifically, gestational mothers (but not fathers) who report higher levels of stress exhibit reduced neural synchrony with their children (aged 3-4 years) in regions essential for attention, working memory, and cognitive control, including the inferior frontal gyrus and the dorsolateral prefrontal cortex (dlPFC) (Azhari *et al.*, 2019; Nguyen *et al.*, 2021).

From a physiological perspective, mothers who exhibit less reactive circulating cortisol response profiles during the Strange Situation paradigm show a paradoxically increased neural activation to infant distress cues within brain regions governing motivation, empathy, and emotion regulation, such as the striatum, the medial prefrontal cortex (mPFC), the anterior cingulate cortex (ACC), and the insula (Laurent *et al.*, 2011). These data demonstrate a direct link between hypothalamic-pituitary-adrenal (HPA) axis dynamics, maternal neural responsiveness, and parenting quality.

Perinatal depression (PND) represents a highly prevalent complication of the perinatal period, affecting an estimated 10-20% of women. Longitudinal quarterly estimates indicate prevalence rates of 7.4% in the first trimester, 12.8% in the second, and 12.0% in the third, culminating in a cumulative gestational prevalence of 20.4%. Antenatal depression (AND) significantly compromises both maternal well-being and fetal development, adversely altering obstetric outcomes and subsequent child cognitive trajectories. Mothers at high risk for AND frequently present with poor self-care (e.g., nutritional deficiencies, substance abuse), interpersonal conflicts, and an elevated risk of future severe mood disorders or suicide.

Fetal and neonatal risks associated with AND include preterm birth, low birth weight, intrauterine growth restriction (IUGR), and neurocognitive developmental deficits. Infants born preterm or with low birth weight face increased susceptibility to neurocognitive impairments, global developmental delays, and psychomotor deficits (Stoll *et al.*, 2004). Over the long term, children exposed to untreated maternal AND exhibit higher rates of behavioral disorders, cognitive delays, and the onset of clinical depression during adolescence (Stein *et al.*, 2014).

Postpartum depression (PPD) constitutes the most frequent clinical complication of childbirth. A recent review by Wenzel *et al.* (2025) identified distinct cortical thickness alterations among mothers with PPD, particularly within regions responsible for empathy (e.g., the insula) and sensory integration (e.g., the parietal lobe). Postpartum depressive symptoms correlate with increased resting-state activity in the right frontal lobe.

Furthermore, mothers with PPD comorbid with high levels of anxiety exhibit significantly weakened functional connectivity among the amygdala, ACC, dlPFC, and hippocampus compared to healthy postpartum controls. Conversely, increased corti-

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cal thickness is observed in frontal and occipitotemporal regions – including the superior frontal gyrus, the cuneus, the lingual gyrus, and the fusiform gyrus – which regulate emotional processing, visual analysis, and maternal responsiveness.

Task-based fMRI paradigms further reveal altered neural processing of emotionally salient, infant-related stimuli in PPD. When exposed to infant crying, healthy comparison mothers show robust activation of the striatum, thalamus, and ACC, whereas depressed mothers demonstrate reduced activation in these regions. Similarly, when viewing their own infant's face, mothers with PPD show reduced functional connectivity between the amygdala and the right insula, suggesting a selective breakdown in the integration of the Salience Network (Wenzel *et al.*, 2025).

Early postpartum mood symptoms also correlate with a reduced recruitment of prefrontal reward-related circuits, specifically the subgenual and pregenual ACC (Chechko *et al.*, 2023). However, among mothers experiencing high depressive symptomatology, an increased striatal response to emotional cues is predictive of more positive and sensitive caregiving, suggesting a compensatory recruitment of the neural reward system to preserve parenting behavior (Morgan *et al.*, 2017).

Paternal Postpartum Depression and Long-Term Outcomes in the Offspring

A meta-analysis by Álvarez-García *et al.* (2024), involving over one million participants across more than 30 countries, established that paternal postpartum depression is a substantial public health issue, with prevalence rates of 9.76% in the prenatal period and 8.75% in the postnatal period, often persisting beyond the first year after childbirth. Depressed fathers exhibit lower emotional availability, reduced rates of positive interaction, and elevated levels of irritability or withdrawal during caregiving routines.

The offspring of depressed fathers face a significantly higher risk of developing internalizing and externalizing symptoms, including anxiety, oppositional defiant behavior, and emotional dysregulation, particularly when paternal withdrawal coincides with critical developmental windows. A longitudinal cohort study of 1,089 American families demonstrated that paternal depression when the child was 3 years old significantly predicted a higher probability of child neglect by age 5. Similarly, paternal depression correlates with a less synchronous and less positive father-infant interactive style, which acts as a direct predictor of escalating behavioral problems in early childhood (Abraham, Feldman, 2022).

Investigating the long-term transgenerational effects of parental mood disorders, Feibel *et al.* (2026) conducted a prospective longitudinal cohort study tracking the timing of exposure to parental depression (from gestation to early adulthood)

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on the offspring's mental health in adulthood (22-27 years). Their primary findings linked parental depression to specific adult offspring phenotypes: depressive symptoms at age 27, anxiety disorders at age 25, clinical psychotic symptoms at age 24, and alcohol use disorders (AUD) at age 22.

Notably, maternal depression starting from the 32nd week of gestation was strongly associated with clinical depression in the offspring at 18 years of age. Maternal depression occurring from 8 months postnatal onward was uniquely predictive of anxiety symptoms in the offspring at age 21.

Conversely, paternal depression showed a robust and significant association with both depression and anxiety in the offspring, extending from middle childhood (5 years) into early adulthood (21 years). Only prenatal maternal depression at the 32nd gestational week was significantly associated with the emergence of psychotic symptoms in the adult offspring, highlighting a unique window of prenatal vulnerability.

Parenthood in Crisis: Etiology and Dynamics of Parental Burnout

In the modern socioeconomic landscape, parents report lower self-efficacy and higher performance pressures compared to previous generations. When individuals face chronic and unmitigated parental stress that exceeds their internal and external coping resources, they become highly vulnerable to Parental Burnout (PB). This distinct psychological syndrome affects both mothers and fathers and is defined by prolonged physical and psychological exhaustion directly linked to the parental role (Bogdán *et al.*, 2025). This exhaustion is typically accompanied by emotional detachment from one's children, overwhelming weariness, and severe self-doubt regarding one's parenting competence (Roskam, Mikolajczak, 2021).

Risk factors that increase vulnerability to PB include a lack of external support systems, single-parent status, a parent's chronic illness, a high number of dependent children, the extremes of parental age (being very young or older parents), professional burnout, pre-existing mental health conditions (e.g., major depressive disorder or generalized anxiety disorder), or caring for a child with chronic medical or neurodevelopmental needs.

The consequences of PB on the offspring are profound; it significantly increases the risk of child neglect, as well as physical and psychological abuse. Over the long term, children exposed to these environments are more likely to develop post-traumatic stress symptoms, engage in self-harm, develop addiction disorders, and exhibit violent behaviors in adulthood (Haj-Yahia *et al.*, 2019). Epidemiological data indicate that 60-80% of neglected children develop insecure attachment styles

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alongside pervasive deficits in executive functions. These impairments affect cognitive domains such as mental flexibility, goal setting, attentional control, emotional regulation, and inhibitory control, in addition to deeply disturbed emotional processing (Herrero-Roldán, Martín-Rodríguez, 2025).

The prevalence of PB is projected to increase, driven by an increasingly fast-paced global culture and a concomitant reduction in the social and temporal resources available to families. This risk is further amplified for the "sandwich generation" – parents who simultaneously manage the care of dependent children and elderly, chronically ill parents – who face a double burden of physical and psychological stress. Over time, these chronic psychological stressors frequently somatize, and in severe clinical manifestations, parental burnout can precipitate active suicidal ideation.

Early, proactive screening and continuous monitoring of families must be prioritized within modern healthcare and public health systems through holistic and multidisciplinary collaboration. Established protective factors against PB include achieving an optimal work-life balance and the availability of informal support networks, such as members of the extended family (grandparents, aunts, uncles) (Mikolajczak, Roskam, 2018). Furthermore, an effective social buffering effect can be derived from peer friendships and community support (Hosokawa, Katsura, 2024).

Salutogenesis: A Systemic and Multidisciplinary Framework

The establishment of a virtuous cycle of health to support contemporary families depends entirely on the dynamic interaction between individual well-being, robust social support, and favorable environmental conditions. When parents are healthy and backed by adequate socioeconomic, social, and relational resources, they execute their parental roles more effectively, experiencing lower baseline stress and demonstrating greater sensitivity to their children's needs. Supporting functional parenting directly facilitates the harmonious development of children, who grow up in conditions of emotional security, solid physical health, normative cognitive development, and prosocial competencies. This healthy development subsequently mitigates intra-familial stressors, enhances the overall domestic climate, and reinforces parental well-being.

This systemic cycle requires key macro-environmental inputs, including universally accessible healthcare and mental health services, family-centered social policies, population-level health literacy, integrated community networks, and legislative protections for work-life balance. Parenthood can no longer be evaluated solely through the lens of individual responsibility; it must be sustained by an integrated infrastructure of resources and public policies that promote health across the entire lifespan.

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Building a true culture of health and well-being requires fostering equitable and health-supportive communities, where citizens are empowered as active co-producers of healthy lifestyles (Tziraki-Segal *et al.*, 2019). The fundamental components of this paradigm shift include comprehensive health education across all social strata, professional training frameworks, and policies that mandate person-centered care. This care must address well-informed citizens, community advocates, and legislative leaders, while simultaneously reinforcing civic engagement and a shared sense of community.

A central role within this salutogenic model is occupied by the social determinants of health (SDOH), such as education level, stable employment, income security, adequate housing, safe built environments, and structural social cohesion.

High priority must be assigned to citizen empowerment and active aging through personalized, lifelong interventions focused on physical activity, nutritional optimization, and active social participation. This aligns with European public health initiatives aimed at preventing frailty and developing urban and social environments designed to incentivize sustainable and healthy behaviors (CSDH, 2008).

Building a robust culture of health requires an intersectoral and multidimensional framework where governmental institutions, healthcare systems, commercial enterprises, local communities, and individual citizens share a collective responsibility. Future research must focus on identifying scalable and culturally adaptable interventions, evaluating their efficacy across diverse socioeconomic landscapes, and formulating evidence-based public policies designed to maximize well-being, build psychological resilience, and preserve the long-term sustainability of healthcare systems throughout the lifespan.

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