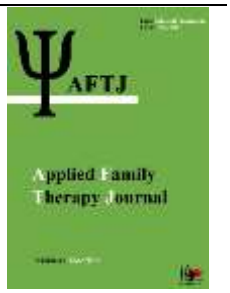
KMAN PUBLISHING INSTITUTE
Journal Website

Article history:
Received 09 January 2026
Revised 15 February 2026
Accepted 25 February 2026
Published online 01 March 2026

Applied Family Therapy Journal

Volume 7, Issue 2, pp 1-11



E-ISSN: 3041-8798

Algorithmic Modeling of Caregiver Systemic Burden in Chronic Illness by Intersecting Partner Neuroticism and Dyadic Coping Mechanisms

Aishath. Naseem[1], Arman. Sargsyan[2*], Zuzana. Hrivnáková[3]

[1] Department of Psychology, Maldives National University, Malé, Maldives
[2] Department of Applied Psychology, Yerevan State University, Yerevan, Armenia
[3] Department of Clinical Psychology, Pavol Jozef Šafárik University, Košice, Slovakia

*** Corresponding author email address**: arman.sargsyan@ysu.am

A r t i c l e I n f o

Article type:
Original Article

How to cite this article:
Naseem, A., Sargsyan, A., & Hrivnáková, Z. (2026). Algorithmic Modeling of Caregiver Systemic Burden in Chronic Illness by Intersecting Partner Neuroticism and Dyadic Coping Mechanisms. *Applied Family Therapy Journal, 7*(2), 1-11.
http://dx.doi.org/10.61838/kman.aftj.5269

A B S T R A C T

Objective: To develop an algorithmic model predicting caregiver systemic burden by evaluating the complex, non-linear intersections between a care-recipient's neuroticism and the couple's dyadic coping mechanisms.

Methods and Materials: A cross-sectional, dyadic study design was utilized, comprising 214 caregiver/care-recipient dyads managing chronic illness in Yerevan, Armenia. Psychometric data were collected using the Zarit Burden Interview (ZBI) for caregiver burden, the Big Five Inventory-2 (BFI-2) for care-recipient neuroticism, and the Dyadic Coping Inventory (DCI) for dyadic coping. Predictive modeling was conducted using a Gradient Boosting Machine (GBM) algorithm with the dataset partitioned into training (80%) and testing (20%) subsets, while SHapley Additive exPlanations (SHAP) were employed to extract feature importance and interaction effects.

Findings: The GBM model exhibited strong predictive performance, accounting for 64%of the variance in caregiver systemic burden on the test set ($R^2 = 0.64$), with a Root Mean Square Error ($RMSE$) of 9.58. SHAP analyses identified care-recipient neuroticism as the most potent predictor of burden (Mean $|SHAP| = 4.72$), followed by caregiver engagement in negative dyadic coping (Mean $|SHAP| = 3.15$) and illness duration (Mean $|SHAP| = 2.09$). Interaction analyses revealed that the detrimental impact of partner neuroticism was exponentially amplified by negative dyadic coping and significantly buffered by active supportive dyadic coping.

Conclusion: Algorithmic modeling effectively demonstrates that caregiver systemic burden is a deeply interdependent phenomenon, highlighting that the psychological toll of a partner's neuroticism is highly conditional upon the couple's underlying dyadic coping architecture.

Keywords: *Caregiver systemic burden, chronic illness, dyadic coping, neuroticism*

1. Introduction

The global epidemiological transition from acute to chronic diseases has fundamentally restructured the landscape of modern healthcare, shifting a profound degree of responsibility from formal medical institutions to the informal family unit. Consequently, family caregivers have emerged as the invisible backbone of chronic illness management. However, this critical role is frequently accompanied by severe, multidimensional distress, collectively conceptualized as caregiver systemic burden. This burden is not a monolithic experience; rather, it manifests uniquely across a vast spectrum of socio-demographic contexts and clinical diagnoses. For instance, caregivers supporting older women experiencing poverty navigate intersectional disadvantages that severely limit their access to essential resources, exacerbating their objective and subjective burden (Chica-Pérez et al., 2025). Similarly, parents caring for adult children with autism spectrum disorder face prolonged, lifelong trajectories of care that uniquely strain financial and emotional reserves (Marsack-Topolewski et al., 2025), a challenge that begins early in childhood as caregivers struggle with daily routines, such as maintaining the oral hygiene of autistic children (Karuna et al., 2024). The chronicity and severity of the patient's condition directly dictate the caregiver's psychosocial reality. Caregivers of patients with highly demanding physiological needs, such as individuals requiring lower-limb amputations (Rodrigues et al., 2025) or those managing transfusion-dependent conditions like thalassemia (Sikandar et al., 2024), face distinct physical and psycho-social challenges that require highly specialized empowerment strategies.

Furthermore, the environmental and systemic context in which caregiving occurs can exponentially amplify this baseline burden. The recent COVID-19 pandemic vividly illustrated how external disruptions to healthcare access and social support systems catastrophically compounded the caring challenges faced by family members of oncology patients (Sharbafchi et al., 2025). In even more extreme contexts, research investigating caregivers in regions experiencing profound, protracted conflict and mass trauma underscores that severe environmental stressors threaten fundamental psychological survival, creating a devastating intersection between caregiving duties and extreme mental health deterioration (Veronese et al., 2025). Even in stable environments, the continuous demands of caring for vulnerable populations, such as disabled elderly individuals, frequently precipitate a downward psychological spiral, culminating in high levels of compassion fatigue and severe burnout, while simultaneously eroding compassion satisfaction (Yang et al., 2025).

While the general strain on family members is well-documented, the dynamics of caregiving within the context of a spousal or romantic partnership warrant distinct clinical and theoretical attention. Partner caregiving fundamentally alters the pre-existing equilibrium of the romantic dyad, forcing a transition from an egalitarian partnership to an asymmetric caregiver and care-recipient dynamic. This shift routinely disrupts the equitable distribution of household tasks, directly correlating with increased subjective burden (Otobe et al., 2023). More profoundly, the intrusion of chronic illness deeply affects the emotional and physical intimacy of the couple, a phenomenon well-documented in the context of Alzheimer's disease and related dementias (Harris et al., 2011). The psychological distress experienced by spousal caregivers is often severe and enduring. Partners providing care to veterans with chronic post-traumatic stress disorder (PTSD) exhibit substantial caregiver burden and psychological distress, driven by the unpredictable behavioral symptoms of the patient (Calhoun et al., 2014). Similarly, women caring for partners with traumatic brain injury (TBI) frequently report diminished perceived health and heavily compromised quality of life (Saban et al., 2016). In the realm of severe neurological and oncological conditions, the suffering of the caregiver is inextricably linked to the patient's decline. Spousal caregivers of partners with brain tumors report profound existential and psychological suffering (Francis et al., 2021), while longitudinal studies in lung cancer reveal a reciprocal cycle of distress, wherein the patient's anxiety and depression continuously exacerbate the spouse's distress and overall burden (Milbury et al., 2013). Consequently, sudden medical events, such as a partner's stroke, precipitate an immediate and sustained drop in the caregiver's life satisfaction, necessitating targeted interventions during and after inpatient rehabilitation (Ostwald et al., 2009).

To navigate this systemic burden, caregivers and family systems deploy a wide array of coping mechanisms, the efficacy of which largely determines long-term psychological outcomes. The adoption of positive coping styles is consistently linked to enhanced family resilience, acting as a crucial buffer against caregiver burden in chronic conditions such as Chronic Obstructive Pulmonary Disease (COPD) (Zhang et al., 2024). The cognitive framing and emotion regulation strategies utilized by the caregiver are

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

paramount; specifically, a caregiver's emotion regulation capacity directly mediates the relationship between their own pain-related beliefs and the subsequent coping strategies adopted by the patient (Alinajimi et al., 2023). Across different developmental and psychiatric landscapes, coping profiles vary significantly. Caregivers of young adults with developmental disabilities exhibit specific coping styles that directly dictate their overall well-being (Singer et al., 2023). In the context of chronic psychiatric conditions, family caregivers of patients with schizophrenia (Tengku Mohd Saifuddin Tengku et al., 2022) and other severe mental disorders (Marzban et al., 2024) employ diverse, and sometimes maladaptive, coping strategies to manage the episodic unpredictability of the illness. Conversely, highly adaptive strategies, such as spiritual coping, have emerged as vital protective factors for caregivers of relatives with severe mental illness, prompting the development of specific nursing interventions to foster this domain (Casaleiro et al., 2024). Even following the ultimate loss of the care-recipient, the coping process continues; bereaved family caregivers rely heavily on positive meaning reconstruction within the dual-process model of grief to navigate their bereavement (Tey & Lee, 2022).

Recognizing that coping does not occur in a vacuum, contemporary psycho-oncology and behavioral medicine have increasingly shifted focus from the individual caregiver to the family system as a whole. Family resilience has been identified as a critical determinant of psychosocial adaptation, particularly in highly stressful contexts such as adolescent and young adult hematological malignancies, where the entire family's systemic response dictates clinical outcomes (Zhang et al., 2025). Consequently, modern therapeutic interventions are increasingly designed to target systemic and dyadic mechanisms. Approaches such as Acceptance and Commitment Therapy (ACT) are being broadly implemented to simultaneously support patients with advanced progressive illnesses, their family caregivers, and the clinical staff (Watt, 2023). Emotion-focused family therapy seeks to directly engage caregivers, improving parental reflective functioning to better serve the psychological needs of the patient (Radosavljevic, 2025). The immediate, real-time dynamics of these familial interactions are now being captured using advanced methodologies like Ecological Momentary Assessment (EMA), providing granular insights into the daily lives of adolescents with anorexia nervosa and their caregivers undergoing family-based treatment (Singh et al., 2025). This emphasis on systemic interaction highlights that the emotional environment created by the caregiver—specifically caregiver emotion socialization—profoundly impacts the psychosocial adjustment of the child or patient, as observed in pediatric cancer contexts (Guthrie et al., 2025). Recognizing the unique vulnerabilities of the dyadic unit, specific randomized trials are now focusing on resilience-based interventions exclusively designed to fortify psychologically distressed partner caregivers (Genter et al., 2021).

Despite the extensive literature documenting caregiver burden and coping, a critical theoretical and methodological gap remains regarding the intersecting influence of the care-recipient's personality traits and the couple's shared coping processes. While individual coping strategies are well understood, chronic illness within a partnership is managed through *dyadic coping*—the interplay of stress signals and coping responses between partners. However, the efficacy of dyadic coping is highly susceptible to the psychological disposition of the care-recipient. Specifically, the personality trait of neuroticism, characterized by a pervasive tendency toward negative emotionality, anxiety, moodiness, and emotional instability, acts as a profound disruptor within the dyadic system. When a care-recipient exhibits high levels of neuroticism, their chronic state of distress continuously saturates the dyadic environment, demanding disproportionate emotional labor from the caregiver. It is hypothesized that the toxic effect of a patient's neuroticism does not simply add to caregiver burden; rather, it fundamentally alters the effectiveness of the couple's dyadic coping mechanisms, creating a compounding systemic burden that is poorly understood in current literature.

Methodologically, the bulk of existing psycho-social research relies on traditional linear statistical frameworks, such as multiple regression analysis, typically represented by the general linear model $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \epsilon$. While these models are effective for isolating the independent main effects of isolated variables, they are inherently limited in their capacity to map complex, non-linear relationships and high-order, multidimensional interactions. The reality of human relational dynamics—particularly the intricate interplay between a specific personality phenotype (neuroticism) and a multifaceted interpersonal process (dyadic coping)—is rarely linear. For instance, the destructive impact of a care-recipient's neuroticism on the caregiver's mental health may remain relatively dormant until a specific threshold of negative dyadic coping is breached, at which point the burden may

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

escalate exponentially rather than additively. To accurately capture the variance (R^2) in caregiver burden driven by these complex, conditional intersections, a paradigm shift toward algorithmic modeling and machine learning is required. Algorithmic approaches, such as gradient boosting or random forests, operate without pre-specified assumptions about the data's distribution or linearity. They are mathematically designed to detect latent, non-linear interaction effects, thereby providing a more highly resolved, ecologically valid architecture of how burden is actually generated within the dyad. By integrating advanced algorithmic modeling into psycho-social research, we can move beyond generalized risk factors to generate precise, personalized predictive models of systemic distress. Therefore, the aim of this study was to develop an algorithmic model to predict caregiver systemic burden by examining the complex intersections between care-recipient neuroticism and dyadic coping mechanisms.

2. Methods and Materials

2.1. Study Design and Participants

This investigation employed a cross-sectional, dyadic study design to examine the interplay of individual and relational factors contributing to caregiver burden. The study sample was recruited from multiple outpatient clinics and patient support networks within Yerevan, Armenia, ensuring a diverse representation of chronic health conditions. Participants were recruited through purposive sampling, targeting couples where one partner was diagnosed with a significant chronic illness and the other self-identified as the primary informal caregiver. Inclusion criteria for the dyads stipulated that the care-recipient must have received a formal diagnosis of a chronic condition (e.g., cancer, chronic heart failure, multiple sclerosis, advanced diabetes) for a minimum of six months prior to the study, both partners had to be over 18 years of age, cohabiting for at least one year, and fluent in Armenian. Exclusion criteria included the presence of severe cognitive impairment in either partner that would preclude informed consent or reliable self-report, or situations where the caregiver received formal financial compensation for their role. After providing written informed consent, a final sample of 214 dyads, comprising a total of 428 individuals, completed the full battery of assessments. The participants were instructed to complete the questionnaires independently to ensure the privacy and honesty of their responses.

2.2. Measures

Data were collected using a structured questionnaire packet translated into Armenian following a rigorous back-translation protocol to ensure semantic and cultural equivalence. The packet included several validated psychometric instruments. To measure the primary outcome variable, caregiver systemic burden, the Armenian version of the Zarit Burden Interview (ZBI) was administered. This 22-item scale assesses the level of perceived burden across various domains, including the caregiver's health, psychological well-being, finances, and social life, with responses rated on a 5-point Likert scale. The care-recipient partner's neuroticism was assessed using the Neuroticism subscale of the Big Five Inventory-2 (BFI-2). This subscale consists of items that evaluate the extent of negative emotionality, such as anxiety, moodiness, and irritability. Both partners completed the BFI-2, but only the care-recipient's neuroticism score was utilized as a primary predictor in the model, consistent with the study's aim. To capture the relational dynamics, the Dyadic Coping Inventory (DCI) was administered to both partners. The DCI is a comprehensive measure that assesses how couples cope with stress together. It yields scores for several dimensions, including Supportive Dyadic Coping (e.g., providing practical and emotional support), Common Dyadic Coping (e.g., joint problem-solving), and Negative Dyadic Coping (e.g., hostile or ambivalent support). Finally, a custom-developed sociodemographic and clinical questionnaire was used to collect essential information, including participant age, gender, educational level, relationship duration, type of chronic illness, and duration since diagnosis.

2.3. Data Analysis

All statistical analyses were conducted using the R programming language for statistical computing. The initial phase of analysis involved data cleaning and screening for missing values, which were handled using multiple imputation techniques where appropriate. Descriptive statistics, including means, standard deviations, and frequencies, were calculated for all demographic, clinical, and psychosocial variables. Internal consistency reliability for each scale's score in the current sample was assessed using Cronbach's alpha (α). The central analysis to address the study's primary objective involved the development of an algorithmic model to predict caregiver systemic burden. A Gradient Boosting Machine (GBM) approach was selected for this purpose due to its high predictive accuracy

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

and its inherent ability to model complex, non-linear relationships and high-order interactions between variables without pre-specification. The total ZBI score served as the continuous outcome variable. Predictor variables included the care-recipient's neuroticism score, the various subscale scores from both partners' DCI reports, and key demographic and clinical covariates (e.g., caregiver age, illness duration). To prevent model overfitting and to evaluate its generalizability, the dataset was randomly partitioned into a training set (80% of the sample) and a testing set (20% of the sample). The model was trained on the training data, and its predictive performance was evaluated on the unseen testing data using metrics such as the Root Mean Square Error ($RMSE$) and the coefficient of determination (R^2). To interpret the complex GBM model and understand the precise impact of each predictor, SHapley Additive exPlanations (SHAP) values were calculated. The SHAP framework allowed for the quantification of each variable's contribution to the prediction of caregiver burden for each individual case, thereby illuminating how the intersection of partner neuroticism and specific dyadic coping mechanisms drives the model's output.

3. Findings and Results

The final sample consisted of 214 dyads. The sociodemographic and clinical characteristics of the caregivers and care-recipients are detailed in Table 1. Caregivers were predominantly female (71.0%) with a mean age of 53.8 years ($SD = 12.1$), while care-recipients had a more balanced gender distribution (48.1% female) and a mean age of 56.2 years ($SD = 11.5$). The average duration of the dyadic relationship was 28.3 years ($SD = 14.2$). The chronic illnesses represented in the care-recipient sample were varied, with the most common being cardiovascular diseases (34.6%), various forms of cancer (25.2%), and advanced diabetes mellitus (18.7%). The mean duration since the primary diagnosis was 5.7 years ($SD = 4.9$).

On average, caregivers reported a moderate level of systemic burden, with a mean Zarit Burden Interview (ZBI) score of 38.4 ($SD = 16.5$), indicating a significant impact on their well-being. The mean score for care-recipient neuroticism was 3.1 ($SD = 0.9$) on a 5-point scale, suggesting a tendency toward negative emotionality within this group. Regarding relational dynamics, both partners reported relatively high levels of supportive dyadic coping and common dyadic coping, while reports of negative dyadic coping were, on average, low. However, substantial variability was observed across all coping subscales, suggesting a wide range of coping effectiveness within the sample.

Table 1

Sociodemographic, Clinical, and Psychosocial Characteristics of the Study Sample (N = 214 Dyads)

Characteristic	Caregivers (n=214)	Care-Recipients (n=214)
Demographics		
Age, *M* (*SD*)	53.8 (12.1)	56.2 (11.5)
Gender, *n* (%)		
Female	152 (71.0)	103 (48.1)
Male	62 (29.0)	111 (51.9)
Relationship Duration (years), *M* (*SD*)	28.3 (14.2)	28.3 (14.2)
Clinical Variables		
Illness Duration (years), *M* (*SD*)	N/A	5.7 (4.9)
Illness Type, *n* (%)	N/A	
Cardiovascular Disease		74 (34.6)
Cancer		54 (25.2)
Diabetes Mellitus		40 (18.7)
Other (Neurological, Renal, etc.)		46 (21.5)
Psychosocial Variables, *M* (*SD*)		
Caregiver Systemic Burden (ZBI)	38.4 (16.5)	N/A
Neuroticism (BFI-2)	2.5 (0.8)	3.1 (0.9)
Supportive Dyadic Coping (DCI)	3.9 (0.7)	3.8 (0.8)
Common Dyadic Coping (DCI)	3.7 (0.9)	3.7 (0.9)
Negative Dyadic Coping (DCI)	1.8 (0.6)	1.7 (0.5)

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

Preliminary correlational analyses were conducted to examine the direct relationships between caregiver burden, care-recipient neuroticism, and the various dyadic coping subscales. As presented in Table 2, caregiver systemic burden demonstrated a strong and significant positive correlation with care-recipient neuroticism ($r = .51, p < .001$), providing initial support for the hypothesis that a partner's negative emotional disposition is a key factor in caregiver distress. Furthermore, caregiver burden was significantly and positively associated with both the caregiver's ($r = .48, p < .001$) and the care-recipient's ($r = .41, p < .001$) report of negative dyadic coping. Conversely, burden was negatively correlated with supportive dyadic coping as reported by both the caregiver ($r = -.35, p < .001$) and the care-recipient ($r = -.39, p < .001$). These findings highlight that while dysfunctional coping patterns are linked to higher burden, supportive interactions are associated with lower burden.

Table 2

Pearson Correlation Matrix of Key Study Variables

Variable	1	2	3	4	5	6
1. Caregiver Systemic Burden	—					
2. Care-Recipient Neuroticism	.51**	—				
3. CG Supportive DC	-.35**	-.29**	—			
4. CR Supportive DC	-.39**	-.33**	.62**	—		
5. CG Negative DC	.48**	.40**	-.25**	-.21*	—	
6. CR Negative DC	.41**	.45**	-.19*	-.28**	.58**	—

The Gradient Boosting Machine (GBM) model demonstrated strong predictive performance in explaining the variance in caregiver systemic burden. When applied to the unseen test set (20% of the sample), the final model accounted for 64% of the variance in ZBI scores ($R^2 = .64$), with a Root Mean Square Error ($RMSE$) of 9.58. This indicates that the model's predictions were, on average, within approximately 9.6 points of the actual caregiver burden scores, a notable level of accuracy given the ZBI's range of 0 to 88.

To deconstruct this predictive performance and understand the drivers of the model, SHapley Additive exPlanations (SHAP) were employed. The overall importance of each predictor, quantified by the mean absolute SHAP value, is presented in Table 3. The analysis revealed that care-recipient neuroticism was, by a considerable margin, the most influential single predictor of caregiver burden. This was followed by the caregiver's own report of negative dyadic coping and the duration of the care-recipient's illness. The care-recipient's perception of supportive dyadic coping also emerged as a significant protective factor, ranking fourth in importance. These top predictors collectively illustrate that caregiver burden is algorithmically best understood as a function of the ill partner's disposition, the functionality of the couple's coping interactions, and the chronicity of the stressor itself.

Table 3

Predictor Importance Ranking for the Gradient Boosting Model Based on Mean Absolute SHAP Values

Rank	Predictor Variable	Mean |SHAP| Value
1	Care-Recipient Neuroticism	4.72
2	Caregiver-Reported Negative Dyadic Coping	3.15
3	Illness Duration (years)	2.09
4	Care-Recipient-Reported Supportive Dyadic Coping	1.88
5	Caregiver Age	1.45
6	Caregiver-Reported Supportive Dyadic Coping	1.21

A deeper examination of the SHAP values revealed critical interaction effects, which were central to the study's objective. The detrimental impact of care-recipient neuroticism was not uniform across all contexts; its effect was significantly moderated by the dyadic coping environment. Specifically, in dyads where caregivers

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

reported high levels of negative dyadic coping (e.g., hostile or ambivalent responses to stress), high care-recipient neuroticism exerted a potent, amplified effect, strongly pushing the model's prediction toward severe burden. Conversely, in the presence of low negative dyadic coping, the same level of partner neuroticism had a substantially weaker impact on predicted burden. Similarly, the protective effect of care-recipient-reported supportive coping was most pronounced when their partner's neuroticism was high. This suggests that active, supportive coping by the ill partner may act as a crucial buffer that mitigates the stress generated by their own negative emotional tendencies, thereby shielding the caregiver from more extreme levels of burden.

4. Discussion

The primary objective of this study was to move beyond traditional linear paradigms by developing an algorithmic model to predict caregiver systemic burden, specifically examining the complex intersections between care-recipient neuroticism and dyadic coping mechanisms. The utilized Gradient Boosting Machine (GBM) demonstrated exceptional predictive capability, accounting for a substantial 64% of the variance ($R^2 = .64$) in caregiver systemic burden. This robust predictive accuracy validates the utility of machine learning approaches in capturing the multidimensional, non-linear realities of psychosocial distress. In alignment with our central hypothesis, the algorithmic extraction of variable importance via SHAP values revealed that care-recipient neuroticism was the most potent predictor of caregiver burden, followed closely by the caregiver's own engagement in negative dyadic coping and the chronicity of the illness. Crucially, the model illuminated significant interaction effects, demonstrating that the destructive psychological impact of a partner's negative emotionality is not absolute; rather, it is heavily amplified or buffered by the specific coping architecture of the marital dyad.

The finding that a care-recipient's neuroticism serves as the primary driver of caregiver systemic burden highlights the deeply intertwined emotional realities of chronic illness within a romantic partnership. Neuroticism, characterized by a persistent vulnerability to anxiety, irritability, and emotional volatility, essentially creates a pervasive environment of chronic stress that the caregiver must continuously navigate. This continuous exposure drains the caregiver's emotional reserves, frequently accelerating the onset of severe burnout and compassion fatigue, while systematically eroding compassion satisfaction (Yang et al., 2025). Our results strongly align with previous longitudinal research in psycho-oncology, which demonstrated that a patient's psychological distress inevitably cascades into their spouse's psychological framework, creating a reciprocal cycle of heightened burden (Milbury et al., 2013). Similar destructive emotional contagion has been observed in partners of veterans suffering from chronic post-traumatic stress disorder, where the unpredictable and volatile behavioral symptoms associated with the patient's condition drastically elevate the caregiver's psychological distress (Calhoun et al., 2014). When a partner experiences intense existential and physical suffering, such as in the context of brain tumors, the caregiver's own psychological equilibrium is severely threatened (Francis et al., 2021). The algorithmic prominence of neuroticism in our model mathematically confirms that managing the physical symptoms of a disease is often secondary to the invisible, exhausting labor of managing a partner's chronic negative affect.

Furthermore, our findings highlight the critical role of relational functionality, specifically the detrimental impact of negative dyadic coping and the protective power of supportive dyadic coping. The model indicated that hostile, ambivalent, or superficial coping responses (negative dyadic coping) from the caregiver ranked as the second most influential predictor of burden. This suggests that when couples fail to tackle the illness as a unified front and instead resort to frustration or emotional withdrawal, the systemic burden exponentially increases. The adoption of specific coping strategies is heavily mediated by the individual's underlying emotional regulation capacities and their illness-related beliefs (Alinajimi et al., 2023). Dysfunctional coping styles are frequently reported among caregivers managing severe mental disorders, significantly compounding their daily challenges (Marzban et al., 2024), as well as in schizophrenia caregiving contexts, where maladaptive strategies are linked to heightened distress (Tengku Mohd Saifuddin Tengku et al., 2022). Conversely, the SHAP analysis revealed that when the care-recipient actively engaged in supportive dyadic coping—acknowledging the caregiver's stress and offering emotional reciprocity—it served as a powerful algorithmic buffer against the toxic effects of their own neuroticism. The presence of positive, supportive coping mechanisms is consistently associated with fostering robust family resilience, effectively mitigating the psychological weight of chronic conditions like COPD (Zhang et al., 2024). By prioritizing shared meaning and mutual support, couples can significantly alter

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

the trajectory of their psychosocial outcomes, a dynamic similarly crucial in maintaining well-being among caregivers of young adults with developmental disabilities (Singer et al., 2023).

The model also identified illness duration as a central predictor, underscoring that caregiving is a chronic, unfolding trajectory rather than an acute event. The chronicity of illness systematically disrupts the foundational elements of the dyad. Over time, prolonged caregiving forces a radical renegotiation of domestic roles, negatively skewing the sharing ratio of household tasks and steadily increasing subjective burden (Otobe et al., 2023). As illnesses progress, particularly conditions like Alzheimer's disease, the foundational intimacy and reciprocal nature of the couple's relationship are profoundly degraded (Harris et al., 2011). The long-term temporal demands are exceptionally draining in lifelong conditions, such as caring for adult children with autism (Marsack-Topolewski et al., 2025), or managing the relentless daily care routines required for autistic children (Karuna et al., 2024). Similarly, chronic physiological demands, such as those faced by caregivers of lower-limb amputees (Rodrigues et al., 2025) or patients with transfusion-dependent thalassemia (Sikandar et al., 2024), require sustained, long-term empowerment strategies to prevent caregiver collapse. The sudden onset of a chronic trajectory, such as following a partner's stroke, causes an immediate deterioration in the caregiver's life satisfaction that persists long after formal rehabilitation concludes (Ostwald et al., 2009). Importantly, this temporal burden does not exist in a vacuum; it is highly sensitive to external socio-environmental pressures. The systemic burden is drastically magnified when caregiving intersects with socioeconomic vulnerabilities, such as older women experiencing poverty (Chica-Pérez et al., 2025), during systemic healthcare disruptions like the COVID-19 pandemic (Sharbafchi et al., 2025), or under the devastating environmental trauma of mass conflict zones (Veronese et al., 2025).

Finally, the non-linear interactions mapped by our algorithm strongly advocate for a systemic, family-centered approach to psychological intervention. Because the emotional socialization within the family unit directly dictates individual adjustment (Guthrie et al., 2025), isolating the caregiver for treatment while ignoring the patient's neuroticism or the couple's coping dynamics is clinically insufficient. The protective buffering effect of supportive coping observed in our model strongly supports the integration of dyadic-level interventions. Approaches such as Acceptance and Commitment Therapy (ACT), which can be simultaneously applied to patients, caregivers, and clinical staff, offer a promising framework for fostering relational flexibility (Watt, 2023). Emotion-focused family therapy, which directly enhances the reflective functioning and emotional engagement of the family unit, is essential for rewriting maladaptive interactive scripts (Radosavljevic, 2025). Cultivating shared family resilience is particularly critical in high-stakes oncology settings (Zhang et al., 2025), and randomized trials evaluating resilience-based interventions specifically tailored for distressed partner caregivers are demonstrating significant efficacy (Genter et al., 2021). To capture the granular shifts in these relational dynamics, advanced methodologies like Ecological Momentary Assessment (EMA) are increasingly vital (Singh et al., 2025). Even in the face of inevitable loss, adaptive dyadic functioning lays the groundwork for healthier bereavement, allowing surviving partners to effectively utilize positive meaning reconstruction strategies (Tey & Lee, 2022). Furthermore, encouraging transcendent or spiritual coping mechanisms can provide profound existential relief for families navigating the darkest realities of severe mental illness (Casaleiro et al., 2024).

5. Conclusion

This study successfully utilized a Gradient Boosting Machine algorithmic model to decode the complex, systemic architecture of caregiver burden within the context of chronic illness. The findings unequivocally demonstrate that a care-recipient's neuroticism is the primary catalyst for caregiver distress, exerting a profound emotional toll that supersedes standard clinical and demographic variables. However, the application of SHAP interaction analysis revealed that this psychological burden is not deterministic; rather, its severity is highly conditional upon the dyadic coping environment. High levels of negative, hostile coping from the caregiver act as a catalyst, exponentially worsening the burden, whereas active, supportive dyadic coping from the ill partner functions as a vital psychological buffer. By mapping these non-linear interactions, this study shifts the conceptualization of caregiver burden from a solitary, individual experience to a deeply interdependent, dyadic phenomenon, highlighting that the psychological disposition of the patient and the relational mechanics of the couple are inextricably linked to the caregiver's ultimate well-being.

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

6. Suggestions and Limitations

Despite the robust predictive capabilities of the algorithmic model, several limitations must be acknowledged. Primarily, the cross-sectional nature of the study design precludes the establishment of definitive causal relationships between partner neuroticism, dyadic coping, and subsequent caregiver burden. While the model accurately predicts variance, it captures only a single temporal snapshot, failing to account for how these complex relational dynamics evolve as the chronic illness inevitably progresses. Furthermore, the reliance on self-reported psychometric assessments introduces the potential for shared method variance and social desirability bias, particularly regarding sensitive topics such as negative dyadic coping and subjective burden. Geographically, the sample was restricted to dyads within Armenia, and while this provides valuable data on an underrepresented population, it limits the broader cross-cultural generalizability of the findings, as coping mechanisms and familial obligations are heavily influenced by cultural norms. Finally, while the GBM framework is highly sophisticated, such machine learning models can be susceptible to capturing sample-specific noise if not carefully interpreted, although strict train-test partitioning was utilized to mitigate this risk.

Future investigations should prioritize longitudinal, prospective study designs to capture the dynamic, fluctuating nature of caregiver burden and dyadic coping over the extended trajectory of a chronic illness. Implementing advanced data collection techniques, such as Ecological Momentary Assessment (EMA) or daily diary methods, would allow researchers to track real-time emotional contagion and micro-interactions between partners, providing a much higher resolution of how neuroticism disrupts daily coping. Additionally, future algorithmic models should be expanded to include a broader spectrum of personality dimensions beyond neuroticism, such as examining how high partner conscientiousness or agreeableness might actively facilitate adaptive dyadic coping. There is also a critical need for cross-cultural replication of these algorithmic models to determine whether the interaction effects between negative emotionality and dyadic coping hold true across different socio-cultural landscapes and diverse healthcare systems. Lastly, clinical trials should be designed to test whether interventions specifically aimed at modifying the identified high-risk interaction pathways mathematically reduce the predicted burden in real-world settings.

Clinically, these findings strongly advocate for a paradigm shift from individualistic caregiver support to comprehensive, dyadic-focused psychosocial care. Healthcare providers must recognize that treating the physiological symptoms of a chronic illness is insufficient if the psychological environment of the marital dyad is highly toxic. Routine clinical practice should incorporate brief screenings not only for caregiver burden but also for the care-recipient's baseline neuroticism and negative affectivity, allowing clinicians to preemptively identify at-risk caregivers before severe burnout occurs. Psychoeducational programs and therapeutic interventions should explicitly target the relational unit, teaching couples concrete supportive dyadic coping skills, such as active empathetic listening, joint problem-solving, and the deliberate reduction of hostile or ambivalent communication. By equipping both the patient and the caregiver with the tools to navigate emotional distress collaboratively, clinical practitioners can effectively buffer the systemic stress of chronic illness, ultimately preserving the mental health and caregiving capacity of the healthy partner.

Authors' Contributions

All authors have contributed significantly to the research process and the development of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

References

Alinajimi, F., Deldar, Z., Dehghani, M., & Khatibi, A. (2023). Emotion Regulation Mediates the Relationship Between Family Caregivers' Pain-Related Beliefs and Patients' Coping Strategies. *Frontiers in Behavioral Neuroscience*, *17*. https://doi.org/10.3389/fnbeh.2023.983350

Calhoun, P. S., Beckham, J. C., & Bosworth, H. B. (2014). Caregiver burden and psychological distress in partners of veterans with chronic posttraumatic stress disorder. *Journal of Traumatic Stress*, *15*, 205-212. https://doi.org/10.1023/A:1015251210928

Casaleiro, T., Martins, H., & Caldeira, S. (2024). Promoting Spiritual Coping of Family Caregivers of an Adult Relative with Severe Mental Illness: Development and Test of a Nursing Intervention. *Healthcare*, *12*(13), 1247. https://doi.org/10.3390/healthcare12131247

Chica-Pérez, A., Correa-Casado, M., Fernández-Sola, C., Granero-Molina, J., Cortés-Rodríguez, A. E., & Hernández-Padilla, J. M. (2025). The Family Caregiver Role From the Perspective of Older Women Experiencing Poverty in a High-Income Country: A Qualitative Study. *Journal of Advanced Nursing*. https://doi.org/10.1111/jan.17043

Francis, S. R., Hall, E. O., & Delmar, C. (2021). Spouse Caregivers' Experiences of Suffering in Relation to Care for a Partner With Brain Tumor. *Cancer Nursing*, *45*(2), E320-E328. https://doi.org/10.1097/ncc.0000000000000935

Genter, P., Høeg, B. L., Hamre, C. J., Andersen, E. W., Dalton, S. O., Ribers, B., & Bidstrup, P. E. (2021). Protocol for 'Resilient Caregivers': A Randomised Trial of a Resilience-Based Intervention for Psychologically Distressed Partner Caregivers of Patients With Cancer. *BMJ open*, *11*(11), e048327. https://doi.org/10.1136/bmjopen-2020-048327

Guthrie, C. S., Boparai, S., Friedman, D. L., Compas, B. E., & Katz, L. F. (2025). Caregiver Emotion Socialization and Child Adjustment in Context of Pediatric Cancer. *Journal of Family Psychology*, *39*(4), 491-502. https://doi.org/10.1037/fam0001323

Harris, S. M., Adams, M., Zubatsky, M., & White, M. B. (2011). A Caregiver Perspective of How Alzheimer's Disease and Related Disorders Affect Couple Intimacy. *Aging & mental health*, *15*(8), 950-960. https://doi.org/10.1080/13607863.2011.583629

Karuna, Y. M., Dutt, A., Shenoy, R., Lee, Y., Thimmaiah, C., Bhat, S. S., Nayak, A., & Rao, A. (2024). A Scoping Review on Parental/Caregiver Challenges in Maintaining Oral Hygiene Among Children With Autism Spectrum Disorder. *International Journal of Paediatric Dentistry*. https://doi.org/10.1111/ipd.13268

Marsack-Topolewski, C. N., Wang, F., & Samuel, P. S. (2025). Characteristics of Adult Children With Autism and Caregiver Burden. *Family Relations*, *74*(2), 931-950. https://doi.org/10.1111/fare.13141

Marzban, A., Fereidooni-Moghadam, M., & Ghezelbash, S. (2024). Coping Strategies Among Family Caregivers of Patients With Chronic Mental Disorders: A Cross-Sectional Study. *Jundishapur Journal of Chronic Disease Care*, *13*(2). https://doi.org/10.5812/jjcdc-120635

Milbury, K., Badr, H., Fossella, F., Pisters, K. M., & Carmack, C. L. (2013). Longitudinal associations between caregiver burden and patient and spouse distress in couples coping with lung cancer. *Supportive Care in Cancer*, *21*(9), 2371-2379. https://doi.org/10.1007/s00520-013-1795-6

Ostwald, S. K., Godwin, K. M., & Cron, S. G. (2009). Predictors of Life Satisfaction in Stroke Survivors and Spousal Caregivers After Inpatient Rehabilitation. *Rehabilitation Nursing Journal*, *34*(4). https://journals.lww.com/rehabnursingjournal/fulltext/2009/07000/predictors_of_life_satisfaction_in_stroke.5.aspx

Otobe, Y., Kimura, Y., Terao, Y., Suzuki, M., Tanaka, S., Kojima, I., Koyama, S., Kusumi, H., & Yamada, M. (2023). Associations between caregiver burden and care receivers' sharing ratio of household tasks among spousal caregivers. *Geriatrics & Gerontology International*, *23*(8), 616-621. https://doi.org/10.1111/ggi.14636

Radosavljevic, D. (2025). Engaging Caregivers In The Service Of Their Child?s Mental Health: An Examination Of Emotion Focused Family Therapy In Relation To Parental Reflective Functioning. https://yorkspace.library.yorku.ca/items/49377dc9-8e11-47d5-aff1-ec79bbfa403b

Rodrigues, D. F., Carvalho, L., & Pinto, C. (2025). Lower-Limb Amputees and Family Caregivers: Challenges, Needs, and Strategies for Empowerment—A Qualitative Study. *Nursing Reports*, *15*(5), 166. https://doi.org/10.3390/nursrep15050166

Saban, K. L., Griffin, J. M., Urban, A., Janusek, M. A., Pape, T., & Collins, E. G. (2016). Perceived Health, Caregiver Burden, and Quality of Life in Women Partners Providing Care to Veterans With Traumatic Brain Injury. *The Journal of Rehabilitation Research and Development*. https://doi.org/10.1682/jrrd.2015.07.0143

Sharbafchi, M. R., Mousavi, S. M., Sheikhani, G., Keyvanara, M., & Ani, S. (2025). Caring Challenges of Family Caregivers of Cancer Patients in the COVID-19 Pandemic: A Qualitative Study. *Iranian Journal of Nursing and Midwifery Research*, *30*(2), 175-181. https://doi.org/10.4103/ijnmr.ijnmr_125_23

Sikandar, A., Anwar, A., Afzal, A., & Nayab, M. (2024). Psycho-Social Challenges and Coping Strategies of Caregivers of Thalassemia Patients in District Gujrat. *Journal of Asian Development Studies*, *13*(1), 945-958. https://doi.org/10.62345/jads.2024.13.1.78

Singer, H., Clarke, E., Schiltz, H. K., & Lord, C. (2023). Caregivers and Coping: Well-Being and Coping Styles Among Caregivers of Young Adults With Developmental Disabilities. https://doi.org/10.1101/2023.02.24.23286429

Singh, M., Austin, A., Lindenbach, D., Steen, H. V., Habina, C., Marcoux-Louie, G., Loeb, K. L., Engel, S. G., Grange, D. L., & Dimitropoulos, G. (2025). Ecological Momentary Assessment for Adolescents With Anorexia Nervosa and Their Parents/Caregivers In Family-Based Treatment. *International Journal of Eating Disorders*, *58*(3), 608-623. https://doi.org/10.1002/eat.24368

Tengku Mohd Saifuddin Tengku, K., Ariaratnam, S., Nikmat, A. W., Abdullah, N. N., & Khing, T. L. (2022). Coping Strategies and Their Associated Factors Among Caregivers of Patients With Schizophrenia in Kuantan, Malaysia. *Frontiers in Psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.1004034

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798

Tey, M. Q., & Lee, G. L. (2022). Understanding Bereavement Experiences and Coping Among Bereaved Family Caregivers in Singapore: Positive Meaning Reconstruction in the Dual Process Model. *OMEGA - Journal of Death and Dying*, *91*(1), 263-280. https://doi.org/10.1177/00302228221133584

Veronese, G., Mahamid, F., Diab, M., Hassouna, B., & Bdier, D. (2025). Beyond Survival: A Qualitative Study on the Intersection of Caregiving, Coping, and Mental Health in Gaza's Ongoing Mass Massacre. *Journal of interpersonal violence*. https://doi.org/10.1177/08862605251336360

Watt, T. G. (2023). Acceptance and Commitment Therapy (ACT) for People With Advanced Progressive Illness, Their Caregivers and Staff Involved in Their Care: A Scoping Review. *Palliative Medicine*, *37*(8), 1100-1128. https://doi.org/10.1177/02692163231183101

Yang, Q. Q., Chen, Y. D., Schwade, M., & Zhang, Q. (2025). Exploring the dynamics of compassion fatigue, compassion satisfaction, and burnout in family caregivers of disabled elderly: A moderated mediation analysis of social support. *Geriatric Nursing*, *65*, 103537. https://doi.org/10.1016/j.gerinurse.2025.103537

Zhang, N., Liu, Y., Yu, X., Tian, Z., Liu, Y., Li, Y., Liu, X., Zhu, H., & Wang, L. (2024). Positive Coping Style and Family Resilience of Caregivers of COPD Patients: The Chain Mediating Roles of Caregiver Burden and Resilience. *Journal of clinical nursing*, *34*(2), 554-564. https://doi.org/10.1111/jocn.17587

Zhang, Y. H., Wang, L., Cao, R., Chen, L., Yuan, H., Li, R., Jiang, X. S., Cheng, Y., Zou, H., Yang, B. X., & Liu, Q. (2025). Family Resilience in Adolescent and Young Adult Patients With Hematological Malignancies: A Qualitative Study of Patients and Family Caregivers. *Psycho-Oncology*, *34*(7). https://doi.org/10.1002/pon.70224

AFTJ Applied Family Therapy Journal
E-ISSN: 3041-8798