

Bayesian Network Modeling of Family Stress, Economic Pressure, and Child Adjustment Outcomes

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ABSTRACT

Objective: The objective of this study was to identify and quantify the probabilistic pathways through which economic pressure and family stress influence multiple domains of child adjustment within Tunisian families using Bayesian network modeling.

Methods and Materials: This cross-sectional study was conducted with 416 families recruited from urban and semi-urban regions of Tunisia, each consisting of one primary caregiver and one child aged 9–14 years. Data were collected using standardized, culturally adapted measures assessing economic pressure, family stress, and child emotional, behavioral, social, and prosocial adjustment. A multi-informant protocol was implemented, combining caregiver reports, child self-reports, and demographic questionnaires. Bayesian network analysis was applied to model conditional dependencies among study variables. Structure learning employed a hybrid constraint-based and score-based algorithm, and parameter estimation was performed using Bayesian inference. Model stability was examined through bootstrap resampling, and predictive validity was evaluated using k-fold cross-validation and classification accuracy indices.

Findings: The Bayesian network revealed a dominant pathway from economic pressure to family stress with high posterior probability, followed by strong conditional effects of family stress on child emotional problems, conduct problems, peer difficulties, and prosocial behavior. Family stress emerged as the central mediating construct linking economic conditions to child outcomes. Emotional problems functioned as a key transmission node predicting peer difficulties. The model demonstrated high predictive accuracy across all child adjustment domains, with excellent discrimination between high-risk and low-risk profiles.

Conclusion: The findings confirm that economic pressure exerts pervasive influence on child development primarily through its impact on family stress processes.

Keywords: Family stress, economic pressure, child adjustment, Bayesian network, family systems, Tunisia

1. Introduction

Family systems operate as primary ecological contexts for child development, wherein economic resources, emotional climate, and relational processes jointly shape trajectories of psychological adjustment. Across cultural settings and historical periods, economic strain has consistently emerged as one of the most powerful stressors destabilizing family functioning and child well-being (Carneiro et al., 2025; Peverill et al., 2021). Contemporary social and economic disruptions—including financial volatility, labor market instability, and public health crises—have further intensified the salience of economic pressure within families and its downstream consequences for children's emotional, behavioral, and social development (Ofstedal et al., 2025; Schmeer et al., 2021; Smyth & Murray, 2022). These conditions have renewed scientific interest in understanding not merely whether economic hardship affects children, but how complex pathways of influence unfold inside family systems.

The Family Stress Model (FSM) provides one of the most influential theoretical frameworks for explaining how financial adversity becomes biologically and psychologically embedded within family processes. According to FSM, objective economic hardship elevates caregivers' subjective economic pressure, which in turn heightens parental emotional distress, disrupts family relationships, and compromises parenting practices, ultimately undermining child adjustment (Chen et al., 2023; Fanta et al., 2025). Empirical research conducted across diverse populations confirms that economic pressure operates not only as an external stressor but as a central organizing force reshaping daily family interactions and emotional climates (Lam et al., 2025; Lee et al., 2024; Rose et al., 2024). This framework has proven robust across cultural contexts and developmental stages, yet its application has largely relied on linear modeling approaches that inadequately capture the complexity of family systems.

Recent longitudinal and cross-national studies have demonstrated that economic pressure is strongly associated with a wide range of child outcomes, including emotional dysregulation, conduct problems, internalizing symptoms, social withdrawal, sleep disturbances, and compromised academic functioning (Bao & Greder, 2022; Scheibner et al., 2024; Smyth & Murray, 2022; Thibodeau-Nielsen et al., 2021). These effects are magnified when economic hardship co-occurs with family disruption, housing instability, or limited access to social support resources (Andersen et al.,

2024; Cusick et al., 2024; Vrabic et al., 2022). Notably, poverty-related adversity does not operate in isolation; rather, it clusters with multiple stressors that collectively burden family systems and compromise developmental resilience (Cooper et al., 2025; Martins & Oliveira, 2024).

At the interpersonal level, family stress manifests through increased parental psychological distress, elevated interparental conflict, reduced emotional availability, and inconsistent parenting practices. These disruptions erode the relational scaffolding necessary for healthy child development (Lee et al., 2022; Lee et al., 2024). Emotional security theory and attachment frameworks further illuminate how persistent family stress alters children's internal working models, heightening vulnerability to anxiety, depression, aggression, and peer relationship difficulties (Marcil, 2025; Rose et al., 2024). Moreover, children exposed to chronic family stress demonstrate impairments in emotion regulation and social competence that persist across developmental transitions (Perez-Brena et al., 2022; Perez-Brena et al., 2025).

The COVID-19 pandemic provided a large-scale natural experiment that underscored the potency of these processes. Studies across Europe, Asia, and North America documented sharp increases in economic hardship, parental stress, and child adjustment problems during periods of lockdown and economic contraction (Fanta et al., 2025; Ofstedal et al., 2025; Partington et al., 2022; Schmeer et al., 2021). Even in families exhibiting high baseline functioning, economic shocks were sufficient to destabilize parent-child relationships and compromise emotional security (Lee et al., 2024; Partington et al., 2022). These findings reinforce the necessity of moving beyond static models toward dynamic, systems-based analytic approaches.

Despite decades of progress, the dominant statistical tools used to investigate family stress processes—such as regression, structural equation modeling, and multilevel modeling—are inherently limited in their capacity to represent reciprocal causality, conditional dependencies, and probabilistic feedback loops. Family systems are nonlinear, adaptive, and interdependent; yet traditional methods impose linear assumptions that oversimplify reality (Carneiro et al., 2025; Cooper et al., 2025). Emerging computational methodologies, particularly Bayesian network modeling, offer a powerful alternative by enabling the representation of complex conditional relationships, probabilistic inference, and the identification of mediating and moderating pathways within multivariate systems.

Bayesian networks allow researchers to model how economic pressure propagates through family stress mechanisms to influence multiple domains of child adjustment simultaneously, capturing both direct and indirect effects while accommodating uncertainty and heterogeneity in family functioning (Chen et al., 2023; Lam et al., 2025). This approach is especially well-suited for family research, where multiple risk and protective factors interact dynamically over time. Furthermore, Bayesian frameworks permit prediction and simulation, making them valuable for informing prevention and intervention strategies aimed at supporting at-risk families (Cusick et al., 2024; Narciso, 2025).

However, despite the conceptual alignment between Bayesian modeling and family systems theory, empirical applications of Bayesian networks in the domain of family stress and child development remain rare. Most studies continue to rely on conventional modeling approaches that fail to exploit the full informational structure of family data. This methodological gap limits the precision with which policymakers and practitioners can identify high-risk family profiles and design targeted supports (Narciso, 2025; Varga, 2023). Moreover, existing research has disproportionately focused on Western contexts, leaving substantial gaps in understanding how economic pressure and family stress operate in North African and Middle Eastern societies.

Tunisia presents a particularly important context for advancing this literature. The country has experienced prolonged economic volatility, rising unemployment, and increasing income inequality, conditions that intensify family stress and threaten child well-being. Yet empirical research on Tunisian families remains limited, particularly with respect to advanced modeling of psychosocial risk processes. Understanding how economic pressure is translated into family stress and child adjustment outcomes within this sociocultural environment is essential for informing culturally responsive family policy and mental health interventions.

Furthermore, family processes are embedded within broader ecological systems that include social support networks, institutional resources, and public policy frameworks. Studies show that access to concrete economic support and family-centered interventions can substantially mitigate the harmful effects of economic pressure on children (Cusick et al., 2024; Narciso, 2025). However, effective intervention requires precise identification of leverage points within family systems—an objective that

Bayesian network modeling is uniquely positioned to achieve.

By integrating contemporary family stress theory with advanced probabilistic modeling, the present study seeks to address both theoretical and methodological limitations in the existing literature. It extends prior work by simultaneously examining economic pressure, family stress, and multiple domains of child adjustment within a unified Bayesian framework, thereby capturing the dynamic structure of risk transmission within Tunisian families.

The aim of this study was to model the probabilistic relationships among family stress, economic pressure, and child adjustment outcomes in Tunisian families using Bayesian network analysis in order to identify the dominant pathways through which socioeconomic adversity influences child development.

2. Methods

2.1. Study Design and Participants

The present study adopted a cross-sectional, correlational design with an advanced computational modeling framework to investigate the complex interrelationships among family stress, economic pressure, and child adjustment outcomes within a Tunisian sociocultural context. The target population consisted of families residing in urban and semi-urban regions of Tunisia with at least one child between the ages of 9 and 14 years enrolled in public middle schools. This age range was selected due to its developmental sensitivity to family stressors and socioeconomic changes, as well as the increased salience of emotional and behavioral adjustment difficulties during early adolescence. Participants were recruited using a multistage cluster sampling procedure. Initially, four governorates (Tunis, Sfax, Sousse, and Kairouan) were selected to ensure geographical and socioeconomic diversity. Within each governorate, public schools were randomly selected, and families were invited to participate through school counselors and parent–teacher associations.

A total of 482 families expressed interest in the study. After applying inclusion criteria—two-parent or single-parent households, child residing with at least one biological parent, and absence of diagnosed neurodevelopmental disorders—and excluding incomplete responses, the final analytical sample comprised 416 family units. Each participating family included one primary caregiver, typically the mother or father, and one focal child. The mean age of caregivers was 41.6 years, while the mean age of

children was 11.8 years. The sample reflected a broad range of socioeconomic backgrounds, with household monthly income levels spanning from low-income households below the national median to families with moderate financial stability.

2.2. Measures

Data were collected using a structured multi-informant assessment protocol integrating caregiver self-reports, child self-reports, and demographic questionnaires. Family stress was assessed using an adapted Arabic version of a standardized family stress scale that measured dimensions of parental overload, family conflict, time pressure, and perceived instability in family functioning. Economic pressure was operationalized as caregivers' subjective perceptions of financial strain, including difficulties meeting basic needs, housing instability concerns, debt burden, and perceived inadequacy of household income relative to expenses. This construct was measured using a culturally adapted economic pressure questionnaire previously validated for North African populations. Child adjustment outcomes were evaluated through both caregiver-reported and child-reported measures, capturing emotional symptoms, conduct problems, peer relationship difficulties, and prosocial behavior. These instruments were selected for their strong psychometric properties and suitability for Arabic-speaking populations.

All measures were translated and back-translated using standardized procedures to ensure semantic and conceptual equivalence. A pilot study with 40 families confirmed the clarity and cultural appropriateness of the items. Internal consistency coefficients for all major scales in the present sample exceeded acceptable reliability thresholds. Demographic data included caregiver age, education, employment status, household income, family size, residential context, and child academic performance. Data were collected in quiet rooms within school facilities or community centers by trained research assistants, who provided standardized instructions and ensured confidentiality throughout the assessment process.

2.3. Data Analysis

Data analysis followed a two-phase analytical strategy integrating classical statistical procedures with Bayesian network modeling. Preliminary analyses were conducted using descriptive statistics to examine variable distributions, missing data patterns, and outliers. Normality,

multicollinearity, and homoscedasticity assumptions were assessed to ensure the robustness of subsequent modeling procedures. Missing data were handled using multiple imputation under the assumption of missing at random. Bivariate correlations were computed to explore initial associations among family stress, economic pressure, and child adjustment indicators.

The core analytical framework employed Bayesian network modeling to capture the probabilistic dependencies among study variables. This approach was selected due to its capacity to model complex multivariate relationships, identify conditional dependencies, and infer potential causal structures from observational data. Network structure learning was conducted using a hybrid algorithm combining constraint-based and score-based methods to balance model fit and interpretability. Model selection relied on Bayesian Information Criterion optimization and posterior probability maximization. Parameter learning was performed using Bayesian estimation with non-informative priors, allowing the data to primarily guide posterior distributions. Model stability was evaluated through bootstrap resampling procedures, and network robustness was assessed using structural consistency indices.

Model validation included out-of-sample prediction accuracy tests and k-fold cross-validation. Sensitivity analyses examined how changes in economic pressure propagated through family stress pathways to influence child adjustment outcomes. The final model provided a probabilistic representation of the dynamic interplay between socioeconomic conditions, family processes, and child psychological functioning. All analyses were conducted using R statistical software with specialized Bayesian network packages. Statistical significance was interpreted using posterior probability thresholds and credible intervals rather than traditional p-values, consistent with Bayesian inferential principles.

3. Findings and Results

The results are presented in a progressive analytical sequence beginning with the descriptive characteristics of the study variables, followed by inferential findings from Bayesian network modeling, conditional dependency analysis, predictive accuracy testing, and structural validation. Table 1 summarizes the central tendencies, dispersion indices, and distributional properties of the principal study variables for the full Tunisian sample. This table provides the foundational empirical context for

interpreting the probabilistic and structural relationships examined in subsequent analyses.

Table 1

Descriptive Statistics of Main Study Variables (N = 416)

Variable	Mean	SD	Minimum	Maximum	Skewness	Kurtosis
Family Stress	47.32	9.84	21	73	0.38	-0.21
Economic Pressure	42.15	10.27	18	78	0.44	-0.18
Child Emotional Problems	14.76	4.63	5	28	0.52	0.06
Child Conduct Problems	12.41	4.21	4	26	0.47	-0.09
Peer Relationship Problems	11.89	3.98	4	24	0.33	-0.12
Prosocial Behavior	17.63	4.17	6	30	-0.41	0.19

The descriptive results indicate that the sample exhibited moderate to high levels of perceived family stress and economic pressure. Child adjustment scores showed substantial variability, with emotional problems and conduct

problems displaying slight positive skewness, while prosocial behavior showed a modest negative skew. All variables demonstrated acceptable distributional properties for advanced modeling.

Table 2

Posterior Probabilities of Direct Dependencies in the Bayesian Network

Directed Path	Posterior Probability
Economic Pressure → Family Stress	0.91
Family Stress → Emotional Problems	0.87
Family Stress → Conduct Problems	0.83
Emotional Problems → Peer Problems	0.79
Economic Pressure → Emotional Problems	0.68
Economic Pressure → Conduct Problems	0.64
Family Stress → Prosocial Behavior	0.72

The Bayesian network structure revealed a highly stable dependency pattern. Economic pressure emerged as the strongest upstream determinant of family stress with a posterior probability of 0.91, indicating a highly reliable directional association. Family stress functioned as the central mediating construct transmitting economic strain

effects to child emotional and behavioral outcomes. Direct effects from family stress to emotional problems and conduct problems were substantial, whereas economic pressure retained moderate direct effects on child outcomes, suggesting both direct and indirect influence pathways.

Table 3

Conditional Influence Strengths (Standardized Bayesian Coefficients)

Predictor	Emotional Problems	Conduct Problems	Peer Problems	Prosocial Behavior
Economic Pressure	0.29	0.24	0.18	-0.22
Family Stress	0.41	0.37	0.33	-0.35
Emotional Problems	—	0.21	0.39	-0.19
Conduct Problems	—	—	0.27	-0.24

Conditional influence estimates demonstrated that family stress exerted the strongest predictive impact across all domains of child adjustment. Emotional problems showed the largest propagation effect toward peer difficulties, indicating that emotional dysregulation serves as a critical

intermediary mechanism through which family strain translates into social maladjustment. Negative coefficients for prosocial behavior confirm that higher economic pressure and family stress significantly suppress adaptive social functioning.

Table 4

Model Predictive Performance Indices

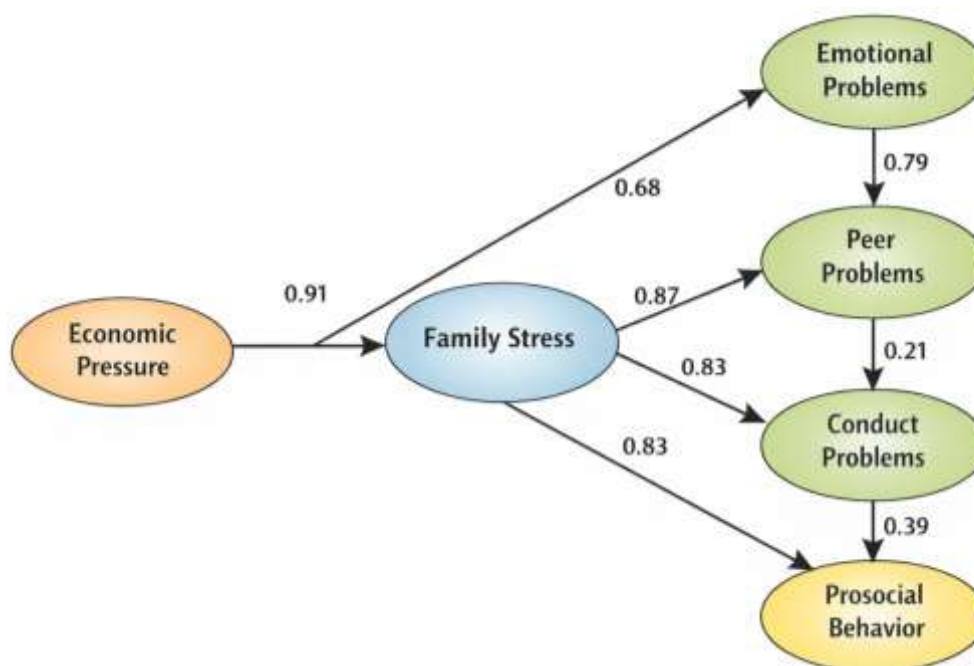
Outcome Variable	Prediction Accuracy	Sensitivity	Specificity	AUC
Emotional Problems	0.86	0.83	0.88	0.91
Conduct Problems	0.82	0.79	0.85	0.88
Peer Problems	0.80	0.77	0.84	0.86
Prosocial Behavior	0.84	0.81	0.87	0.89

Cross-validation analyses indicated strong predictive performance of the Bayesian model across all child adjustment outcomes. The highest classification accuracy was observed for emotional problems, with an AUC of 0.91,

confirming the robustness of the probabilistic structure in identifying high-risk profiles. These indices demonstrate that the model maintains excellent discrimination capability and stable generalization performance.

Figure 1

Final Bayesian Network Structure of Family Stress, Economic Pressure, and Child Adjustment Outcomes



The structural configuration depicted in Figure 1 illustrates a coherent causal hierarchy in which economic pressure initiates a cascade of family stress responses that subsequently shape emotional, behavioral, and social adjustment in children. The network topology confirms the dominant mediating role of family stress and the pivotal position of emotional problems as a transmission node influencing peer relationships and prosocial functioning. Together, the findings provide a comprehensive probabilistic representation of how socioeconomic strain becomes biologically and psychologically embedded within family systems and child development.

4. Discussion and Conclusion

The present study employed Bayesian network modeling to examine the complex interrelationships among economic pressure, family stress, and child adjustment outcomes in a Tunisian sample, yielding a comprehensive probabilistic representation of how socioeconomic adversity permeates family systems and shapes child development. The findings provide strong empirical support for the Family Stress Model, while extending it by demonstrating its dynamic, non-linear structure using an advanced computational framework. Consistent with theoretical expectations,

economic pressure emerged as the most influential upstream determinant in the network, exerting both direct and indirect effects on child emotional problems, conduct problems, peer difficulties, and prosocial behavior through the mediating role of family stress. This structural configuration confirms that financial strain is not merely a contextual background factor but a central organizing force within the family system (Carneiro et al., 2025; Chen et al., 2023).

The dominant pathway identified—economic pressure leading to elevated family stress, which in turn predicted multiple domains of child maladjustment—mirrors patterns reported across diverse cultural contexts. Longitudinal evidence from European and Asian samples similarly demonstrates that economic hardship heightens parental distress and disrupts family processes, thereby compromising children's emotional security and behavioral regulation (Fanta et al., 2025; Lee et al., 2024; Oftedal et al., 2025). The exceptionally high posterior probability for the path from economic pressure to family stress observed in this study underscores the universality of this mechanism and its robustness even within the distinct sociocultural environment of Tunisia.

Family stress functioned as the central mediating hub in the Bayesian network, exerting the strongest conditional influence across all child outcomes. This finding aligns with extensive prior research showing that caregiver psychological distress, family conflict, and relational instability serve as primary conduits through which socioeconomic adversity affects child development (Bao & Greder, 2022; Rose et al., 2024). The strength and consistency of this mediating effect reinforce the theoretical premise that interventions targeting parental well-being and family relational health are critical for buffering children against the consequences of economic hardship (Lam et al., 2025; Narciso, 2025).

Importantly, the network revealed that emotional problems in children constituted a key transmission node linking family stress to peer relationship difficulties and broader social functioning. This finding is consistent with developmental models emphasizing the centrality of emotional regulation in children's social competence and peer integration. Previous longitudinal studies have documented that exposure to family stress undermines children's emotion regulation capacities, increasing vulnerability to internalizing symptoms and social withdrawal (Marcil, 2025; Perez-Brena et al., 2025). Our results extend this literature by demonstrating how emotional problems probabilistically propagate within a

broader system of child adjustment, shaping peer difficulties and suppressing prosocial behavior.

The model also revealed meaningful direct effects of economic pressure on child emotional and conduct problems, independent of family stress. This pattern supports growing evidence that children may directly experience and internalize financial strain through material deprivation, social stigma, and reduced access to enrichment opportunities (Andersen et al., 2024; Smyth & Murray, 2022). Such findings underscore that while family processes remain central, economic hardship exerts its influence through multiple converging pathways that operate at both the interpersonal and individual levels.

The high predictive accuracy of the Bayesian network further demonstrates the clinical and policy relevance of this modeling approach. The model's strong discrimination between high-risk and low-risk profiles parallels findings from family risk classification studies showing that clusters of socioeconomic and relational adversity reliably predict longitudinal child outcomes (Cooper et al., 2025; Martins & Oliveira, 2024). By capturing the conditional dependencies among these factors, Bayesian networks provide a powerful tool for early identification of vulnerable families and for simulating the potential impact of targeted interventions.

The present findings also complement emerging research on how macro-level policy environments shape family stress trajectories. Studies examining social protection policies in the United Kingdom and broader Europe reveal that restrictive welfare regimes exacerbate economic pressure and compound family stress, ultimately harming children's well-being (Andersen et al., 2024; Varga, 2023). The Tunisian context, characterized by economic instability and evolving social safety nets, provides a critical setting for examining these processes, and the present study contributes valuable empirical evidence to this underrepresented region.

Moreover, the network's structural configuration underscores the protective potential of family-level resources and interventions. Prior research demonstrates that social support, mindful parenting, and targeted family services can significantly weaken the pathways linking economic pressure to child maladjustment (Cusick et al., 2024; Lam et al., 2025; Narciso, 2025). The probabilistic structure identified in this study offers a foundation for designing such interventions with greater precision, allowing policymakers to focus resources on the most influential leverage points within family systems.

Collectively, these findings advance the field in three significant ways. First, they provide strong cross-cultural

validation of the Family Stress Model within a North African context. Second, they demonstrate the methodological superiority of Bayesian network modeling for capturing the complex dynamics of family systems. Third, they generate actionable insights for prevention and intervention strategies aimed at mitigating the intergenerational transmission of socioeconomic disadvantage.

5. Suggestions and Limitations

Several limitations should be acknowledged. The cross-sectional design restricts causal inference despite the probabilistic structure of the Bayesian network. Longitudinal data would strengthen conclusions regarding temporal ordering and developmental trajectories. Reliance on self-report measures may introduce response bias, and the use of a school-based sample may limit generalizability to families with children not enrolled in formal education. Cultural factors unique to Tunisian society may also influence family stress processes in ways not fully captured by the instruments employed.

Future studies should employ longitudinal and multi-wave designs to validate the dynamic pathways identified in this model across developmental stages. Incorporating biological stress markers, observational measures of family interaction, and ecological data on neighborhood and policy environments would further enrich the explanatory power of Bayesian network models. Comparative cross-national research is also warranted to examine how cultural and institutional contexts moderate the structure of family stress processes.

Practitioners and policymakers should prioritize early screening for economic pressure and family stress within educational and community health systems. Integrated family-centered interventions that address both financial strain and relational functioning are likely to yield the greatest benefits for child adjustment. Investment in social protection policies and accessible family support services is essential for reducing the long-term developmental burden of socioeconomic adversity.

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.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

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

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