



Social Support During Pregnancy Modifies the Association Between Maternal Adverse Childhood Experiences and Infant Birth Size

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Abstract

Introduction Adverse childhood experiences (ACEs) can deleteriously affect health, including pregnancy and birth outcomes occurring later in life. Identification of modifiable factors during pregnancy that buffer the ill effects of adversity is warranted. Social support during pregnancy can promote better birth outcomes, yet it is unknown whether it could also mitigate perinatal risks stemming from ACEs. Thus, this study considers multiple forms of social support in pregnancy as modifiers of an ACEs and fetal growth association. **Methods** Data were collected from mother and infant pairs from an ongoing prospective birth cohort. Women enrolled around 27 weeks gestation and completed gold-standard assessments of ACEs and social support. Infant cephalization index scores [(head circumference /birthweight) × 100; a marker of asymmetric fetal growth] were derived. Multivariable regression models tested main effects and interaction between ACEs and social support in relation to infant cephalization. **Results** Higher levels of ACEs were associated with higher cephalization scores ($\beta = 0.01$, $SE = 0.01$, $p < 0.05$) whereas higher social support was associated with lower cephalization scores ($\beta = -0.03$, $SE = 0.01$, $p < 0.05$). A significant interaction was observed showing a protective effect of social support among those with low (0 events) and moderate (1–3 events) ACEs but not among those with high ACEs (4+ events; $p < 0.05$). Tangible and emotional support, but not information support, contributed to the associations. **Discussion** Maternal ACEs can deleteriously affect birth size, yet social support during pregnancy provides some buffer from its enduring effects. Interventions designed to enhance pregnancy social support may not only improve maternal wellbeing, but may also safeguard infant health.

Keywords Adverse childhood experiences · Social support · Cephalization · Birth size

Significance

What is already known on this subject? Childhood adversity can deleteriously affect women's health over the life course, including pregnancy health and birth outcomes. Other research shows that social support during pregnancy can promote healthy birth outcomes. It is unknown whether

social support during pregnancy can buffer the ill effects of childhood adversity and promote better birth outcomes.

What this study adds? This study provides the first evidence that while experiences of childhood adversity can contribute to poorer birth size outcomes, social support during pregnancy can provide some buffer and promote better birth outcomes.

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Introduction

Evidence is accumulating that adverse childhood experiences (ACEs) can affect health for a lifetime (Berens et al. 2017; Shonkoff et al. 2009). Children who experience significant psychosocial adversity often grow up to have increased risk for a wide range of chronic conditions, including cardio-metabolic diseases, mental illness, substance abuse as well as suffer premature mortality (Danese et al. 2009; Felitti et al. 1998; Kelly-Irving et al. 2013; Mersky et al. 2013;

Thomas et al. 2008). Adversity during the highly plastic period of early life may program and dysregulate developing body systems, which in turn influences later disease risk (Berens et al. 2017; Gluckman et al. 2005). Thus, the ill effects of ACEs can endure and compromise health for a lifetime.

Given their lasting effects, reproductive and pregnancy health could likewise be affected among women with a history of ACEs. While several studies have shown that chronic stress and trauma *during pregnancy* can contribute to poor birth outcomes (Brunton 2013; Dunkel Schetter 2011), just a few studies have considered the role of adversity *prior to pregnancy* on birth and infant outcomes. One study that considered ACEs in association with infant birth size (n=2303) found that higher levels of physical, emotional and sexual traumas occurring before age of 18 (assessed during pregnancy) was associated with lower birthweight, with smoking during pregnancy mediating the associations (Smith et al. 2016). Higher levels of these adversities were also correlated with several participant characteristics, including single marital status, lower education, greater likelihood to smoke and/or use illicit drugs in pregnancy, lower social support, and increased risk for psychiatric disorders. Similarly, a case-control study (n=622) found that a high ACE score (≥ 2 events; a retrospective report of early life stressors and traumatic events occurring prior to age 18) was associated with twofold elevated odds of spontaneous preterm birth (Christiaens et al. 2015). However, a review of six studies of maternal history of child sexual abuse (e.g., unwanted forced sex or sexual activity before the age of 15) and gestational age noted mixed findings; just half observed a positive association with preterm birth (Wosu et al. 2015).

While the evidence is suggestive, research is needed to better understand whether and how ACEs can affect birth outcomes. The extant research has focused on traditional perinatal risk markers (gestational age, birthweight). Intrauterine growth restriction and asymmetric fetal growth have not been considered in the context of ACEs, yet could yield insights into the mechanisms through which adversity affects perinatal and offspring outcomes. For example, vascular/placental induced asymmetric fetal growth can contribute to brain sparing during fetal development which is in turn associated with significant neurodevelopmental risks for offspring (Harel et al. 1985; Leitner et al. 2007). Given that ACEs are associated with gestational age and birthweight, ACEs may also contribute to fetal growth restriction. This hypothesis has not previously been tested.

The identification of modifiable positive factors during pregnancy that could buffer the ill effects of ACEs is warranted. Positive factors do not simply reflect the absence of risk and instead are independent assets that promote health and resilience (Kobau et al. 2011). One positive factor is social support, which refers to the perception that one is

cared for and valued by others, and being part of a social network (Taylor 2011). The types of assistance people receive can be characterized as emotional (e.g., providing feelings of belongingness), instrumental (e.g., provision of money), and informational (e.g., provision of knowledge) (Taylor 2011). Social support during pregnancy may moderate the effects of psychosocial distress during pregnancy. A recent meta-analysis of 16 studies found that low social support during pregnancy, measured in a variety of ways, was associated with increased odds of preterm birth, with stronger associations among women with high psychosocial stress (Hetherington et al. 2015). Another study (n=235) found higher levels of perceived frequency and adequacy of intimate partner support, but not social network support, buffered the ill effects of depression during pregnancy and promoted longer gestations, but not differences in birthweight (Nylen et al. 2013). Recent work among non-pregnant women has shown that safe, supportive, and nurturing relationships can mitigate risks for depression, poor physical health, and substance use stemming from early life adversity (Jaffee et al. 2017). No study considered whether social support during pregnancy would similarly modify the association between maternal history of ACEs and birth size outcomes.

We examined the independent effects and joint contribution of maternal ACEs and social support during pregnancy in relation to infant birth size. As most adversity and birth outcomes research has focused on gestational age and traditional size markers like birthweight, we focus on a measure of birth size indicative of asymmetric fetal growth and neurodevelopmental risk (cephalization index; a ratio of head circumference to birthweight) (Leitner et al. 2007). Moreover, as different types of social support may suggest different intervention approaches for practitioners, we consider multiple domains of social support as potential modifiers of the ACEs and birth size association. We tested our hypotheses using prospective data from an ongoing birth cohort of women and their infants and controlled for a robust set of social and biological covariates. This study is among the first to test whether social support during pregnancy can mitigate risk associated with ACEs and promote healthy fetal growth.

Methods

Study Population

Participants were part of the Albany Infant and Mother Study (AIMS), a prospective examination of pregnant women and their infants born at Albany Medical Center (Albany, New York, USA). English speaking women, 18–40 years old, with singleton pregnancies were eligible to participate. Women enrolled on average at 27 weeks gestation at an outpatient obstetrics clinic. At the enrollment visit, participants

completed a set of self-report questionnaires that assessed exposures during and prior to pregnancy. Following the birth, a structured medical record review was conducted by physicians to obtain clinical information on maternal health, delivery, and infant characteristics, including birth size information. Enrollment began in June 2015 and is ongoing. Three-hundred mother-infant pairs are targeted for enrollment. This complete case analysis includes the first 126 participants. Informed consent was obtained from all participants prior to inclusion in this study. Protocols and informed consent documents were approved by Institutional Review Boards at Albany Medical Center and the University at Albany State University of New York. Thus, all procedures performed in this study of were in accordance with the ethical standards of the institutional research committees and with the 1964 Helsinki declaration and its later amendments.

Measures

Adverse Childhood Experiences was assessed with the ACEs questionnaire (Felitti et al. 1998), which is a 10-item retrospective account of adversities experienced by the pregnant woman prior to age 18 and include: neglect (emotional, physical), abuse (emotional, physical, sexual), and household dysfunction (witness of domestic violence, household member was imprisoned, household member had mental illness, drug/alcohol abuse in the home), and parental separation or divorce. Participants indicated whether each event occurred and responses were summed. ACEs scores were treated continuously in primary analyses. A categorical variable reflecting low (0 events), moderate (1–3 events), and high adversity (4 or more events) was derived following established cut points (Felitti et al. 1998) and used to graphically plot interaction effects.

Social support was assessed with the 12-item Interpersonal Support Evaluation List ($\alpha=0.86$) (Cohen and Hoberman 1983), which measures the perceived availability of social resources and relationships. The scale lists a set of statements that participants report how true they perceive those scenarios to be for themselves on a four point Likert scale (e.g., If I were sick, I could easily find someone to help me with my daily chores). Total support and three subscale scores were derived reflecting belonging support ($\alpha=0.70$; e.g., emotional support, availability of companionship), tangible support ($\alpha=0.66$; e.g., material aid), and appraisal support ($\alpha=0.72$; e.g., availability of others for advice). Total and subscale scores are simple unweighted summary scores which were standardized (mean=0, SD=1) to facilitate interpretation and treated continuously in analysis. Higher scores indicated more support. A dichotomous total support variable reflecting high and lower levels of support was derived and used to graphically plot interaction effects. As there are no established cut points, we classified the top

tertile of the distribution as having high support. Sensitivity analyses were conducted using more extreme cut points (e.g., quartiles). As the patterns of associations were similar, we used the tertile dichotomy as it was the most balanced between sensitivity to detect effects and statistical power.

Anthropometric measurements of the newborn were conducted in the delivery room by clinical staff using standard protocols and instrumentation. Information on infant birth weight (grams) and head circumference (centimeters) were abstracted from medical records and used to calculate the cephalization index [(head circumference cm/birthweight g) \times 100]. This index reflects the degree of asymmetric intrauterine growth, with higher scores indicating potential brain sparing during gestation and offspring neurodevelopmental vulnerability (Harel et al. 1985; Leitner et al. 2007). Cephalization scores were continuous in analysis. Dichotomous measures of other birth outcomes were not considered due to low prevalence (e.g., $n=5$ preterm births, $n=10$ low birth weight infants).

Covariates were selected a priori based on their potential to confound the associations (Rothman and Greenland 1998) and included demographic, maternal health, delivery, and infant factors. Demographics included self-reported maternal age, race/ethnicity (white versus black/Hispanic/other) and education attainment (high school or less versus more than high school). Maternal health factors included pre-pregnancy body mass index (weight in kilograms/height in meters²; calculated from self-reported height and weight), self-reported smoking during pregnancy (yes/no), depressive symptoms during pregnancy assessed with the Edinburgh Postnatal Depression Scale (Cox et al. 1987) (EPDS; $\alpha=0.89$) and dietary patterns. The EPDS is a 10-item scale validated for use in perinatal populations that assesses the intensity of depressive symptoms in the past week, focusing on the cognitive and affective features of depression rather than somatic complaints. Total EPDS scores were used in analysis. Dietary patterns during pregnancy were assessed with a 25-item food frequency questionnaire and scores were derived via factor analysis (Michaud et al. 2005; Willett 1998). “Western” diets were characterized by higher consumption of red meats, processed meats, refined grains, high-fat dairy products, potatoes, and sugar sweetened beverages. “Prudent” diets were characterized by higher consumption of fruits, vegetables, legumes, whole grains, and low fat dairy. Delivery factors included parity (nulliparous or not), and mode of delivery (c-section, vaginal). Infant factors included gestational age at delivery (weeks) and infant sex, which were abstracted from medical records.

Statistical analysis

Descriptive statistics were generated and bivariate associations between maternal ACEs, social support during

pregnancy, infant cephalization index and covariates were assessed via Pearson's correlations. Multivariable linear regression models assessed the independent main effects of maternal ACEs and social support during pregnancy in relation to infant cephalization, controlled for all covariates. Next, we tested whether social support during pregnancy modified the association between ACEs and infant cephalization following standard methods for testing continuous interactions (Aiken and West 1991; Quinn and Keough 2002). Specifically, we constructed a multiplicative interaction term for ACEs and total support and fit a fully adjusted linear regression model that included the main effects and interaction term. To interpret the interaction effect, we plotted adjusted mean infant cephalization index scores according to high, medium and low levels of ACEs, and high and lower levels of total social support. Additional fully adjusted interaction models were also fit for each social support subscale to determine which domain of support modified the association between ACEs and cephalization. Statistical significance was determined by p -values < 0.05 and 95% confidence intervals.

Results

Participant characteristics are listed in Table 1. Women were on average 29 years old, 40.5% belonged to a racial/ethnic minority group, 38% had a high school education or less, had an average pre-pregnancy BMI of 29.1, 35% were nulliparous, 13.5% smoked during pregnancy, and the average depressive symptoms score was 8.7 (range 0–25). 34% of infants were born via C-section, 51% were male, and babies were born on average at 38.5 weeks gestation (range 32.1–42.0). The mean cephalization index was 1.04 (range 0.73–1.58). Women experienced on average 2.8 ACEs (range 0–9 events), with 23% reporting no childhood adversity, 43% reporting moderate adversity, and 34% reporting high adversity.

Table 2 lists bivariate correlations between infant cephalization, maternal ACEs, social support during pregnancy, and covariates. Higher levels of ACEs were positively correlated with cephalization ($r = 0.25$, $p < 0.01$). Total social support was negatively correlated with cephalization ($r = -0.20$, $p < 0.05$). ACEs and total social support during pregnancy were inversely correlated ($r = -0.42$, $p < 0.001$). Of the three social support domains, tangible support was most strongly correlated with infant cephalization ($r = -0.28$, $p < 0.001$). ACEs was correlated with infant birthweight ($r = -0.20$, $p < 0.05$) but not head circumference ($r = -0.04$, $p > 0.05$). Social support was correlated with both birthweight ($r = 0.24$, $p < 0.01$) and head circumference ($r = 0.19$, $p < 0.05$).

Table 1 Descriptive statistics for participant characteristics (n = 126)

	% or mean (SD)
Maternal adverse childhood experiences	2.8 (2.4)
Low childhood adversity (0 events)	23%
Moderate childhood adversity (1–3 events)	43%
High childhood adversity (4 or more events)	34%
Age, years	28.9 (5.3)
Race, Black/Hispanic/other	40.5
Race, white	59.5
Education attainment, high school or less	38.1
Education attainment, more than high school	61.9
Smoking during pregnancy, yes	13.5
Smoking during pregnancy, no	86.5
Depressive symptoms during pregnancy	8.7 (5.7)
Maternal western diet score	40.2 (15.4)
Maternal prudent diet score	22.4 (7.2)
Pre-pregnancy BMI	29.1 (8.7)
Nulliparous, yes	34.9
Nulliparous, no	65.1
Mode of delivery, c-section	34.1
Mode of delivery, vaginal	65.9
Infant sex, male	50.8
Infant sex, female	49.2
Gestational age at birth, weeks	38.5 (1.6)
Infant birthweight, grams	3318 (543.7)
Infant head circumference, centimeters	33.6 (1.9)
Infant cephalization index	1.04 (0.15)

Table 3 lists fully adjusted multivariable linear regression models for the associations between maternal ACEs, social support during pregnancy, and infant cephalization index. Maternal ACEs was positively associated with cephalization whereas social support was negatively associated with cephalization adjusting for all covariates (Models 1 and 2). There were no significant independent effects of ACEs and social support when in the model together (Model 3). There was a significant interaction between ACEs and social support (Model 4). R^2 for the final model including the interaction term accounted for 39% of the variability in infant cephalization.

Figure 1 shows a protective effect of high social support during pregnancy among those with low and moderate levels of adversity. Those with low social support had infants with the highest cephalization scores across all levels of ACEs. Those with high social support who also had low adversity had infants with the lowest cephalization scores. This protective effect of high support was evident among those with moderate levels of adversity, yet was less robust. There was no protective effect of high support among those with the highest levels of adversity.

Table 2 Pearson's correlations coefficients for the bivariate associations between infant cephalization index, maternal adverse childhood experiences, social support during pregnancy, and covariates

	Cephalization index	Adverse childhood experiences	Total social support
Infant cephalization index	1.0		
Adverse childhood experiences	0.25**	1.0	
Total social support	-0.20*	-0.42***	1.0
Tangible support	-0.28***	-0.42***	0.92***
Belonging support	-0.18*	-0.43***	0.83***
Appraisal support	-0.10	-0.26**	0.87***
Maternal age	-0.005	0.03	-0.001
Race, Black/Hispanic/other	0.19*	0.13	-0.27**
Education, high school or less	0.10	0.08	-0.13
Smoking during pregnancy	0.07	0.15 ⁺	-0.08
Depressive symptoms	0.07	0.37***	-0.53***
Western diet score	0.15 ⁺	0.22*	-0.06
Prudent diet score	0.09	0.07	0.12
Pre-pregnancy BMI	0.12	0.19*	-0.16 ⁺
Nulliparous	0.02	-0.07	0.11
C-section delivery	-0.02	-0.13	0.01
Infant sex, male	0.15 ⁺	-0.001	-0.02
Gestational age at birth	-0.52***	-0.23**	0.12
Birthweight	-0.98***	-0.20*	0.24**
Head circumference	-0.54**	-0.04	0.19*

⁺p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001

Table 3 Multivariable linear regression models testing the main effects and interaction associations between maternal adverse childhood experiences and social support during pregnancy in relation to infant cephalization index

	Model 1	Model 2	Model 3	Model 4
Adverse childhood experiences	0.01 ⁺ (-0.001, 0.02)		0.01 (-0.01, 0.02)	0.01 (-0.003, 0.02)
Social support during pregnancy		-0.03* (-0.06, -0.001)	-0.02 ⁺ (-0.05, 0.004)	-0.06** (-0.10, -0.01)
Interaction				
Child adversity × social support				0.01* (0.001, 0.02)
R ²	0.34	0.37	0.35	0.39

Cell entries are β (95% confidence limits). Models are adjusted for demographics (maternal age, race/ethnicity, education), maternal health (pre-pregnancy body mass index, smoking, depression, diet), delivery factors (parity, delivery mode), and infant factors (gestational age at delivery, infant sex)

⁺p < 0.10, *p < 0.05, **p < 0.01

Fully adjusted multivariable linear regression models assessed which domain of social support modified the association between ACEs and cephalization. Significant interactions were observed for ACEs with tangible ($\beta = 0.004$, SE = 0.002, $p = 0.01$), and belonging support ($\beta = 0.003$, SE = 0.002, $p = 0.02$), but not appraisal support ($\beta = 0.002$, SE = 0.001, $p = 0.14$).

Discussion

In this study, we found divergent associations between ACEs and social support during pregnancy with asymmetry in fetal growth: an increasing number of ACEs was

associated with increased cephalization scores whereas greater social support was associated with less. The associations between ACEs and the component parts of the cephalization index indicate that adversity contributed to smaller and lighter infant bodies but not reduced head circumferences, which suggest the possibility of brain sparing during fetal development. The interaction effect indicated that social support during pregnancy buffered the deleterious effects of ACEs on cephalization among those with low and moderate levels of ACEs, but not among those with the highest levels of ACEs. The results were particularly noteworthy as we controlled for important social and biologic factors that could affect fetal growth. Our findings illustrate that maternal ACEs can influence

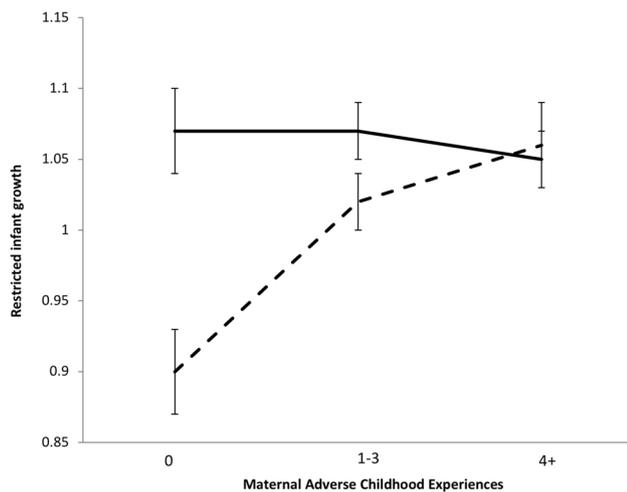


Fig. 1 Adjusted mean infant cephalization indices according to level of maternal adverse childhood experiences and social support during pregnancy. Solid line represents women with low social support. Dotted line represents women with high social support. Error bars indicate 95% confidence intervals

birth size for the next generation, and also highlight social support a modifiable psychosocial asset that may help mitigate risk.

The protective effect of social support was graded across low to moderate levels of adversity, but dissipated completely at high levels of adversity. This may be due to severe ACEs being more prevalent among the high adversity group. The most common ACE reported among the moderate group was parental divorce or separation (66%) whereas the most prevalent forms of adversity experienced by the high group was emotional cruelty (86%), and sexual abuse (70%). Thus, social support may promote resilience among women with histories of low to moderate levels of less severe forms of adversity. Women with significant childhood trauma may need more intensive intervention to promote well-being, healthy pregnancies, and infant outcomes.

Different types of social support during pregnancy modified the ACEs and infant cephalization association: tangible and belonging support, but not appraisal support, were significant. Tangible supports may provide a buffer from the deleterious perinatal effects of ACEs via having someone to provide transportation to prenatal care appointments and provide financial resources that promote pregnancy health (e.g., purchasing health insurance). For belonging support, the presence of others to engage in social activities and provide emotional support could provide outlets for emotional expression and stress relief, and promote positive emotions which could protect fetal growth. Appraisal support relates to the availability of others to provide advice and information. Between frequent contacts with medical providers and accessibility of the internet, advice and information can be

readily accessed regardless of the number of social relationships one has. Thus, this form of support may have less applicability in this context.

As childhood is a sensitive period of human development, ACEs may become biologically embedded to affect health across the life course through the programming of body systems including the hypothalamic–pituitary–adrenal (HPA) axis (Berens et al. 2017). This systemic pathway involves neuroendocrine signaling between the hypothalamus and pituitary glands in the brain and the adrenal glands and regulates the body’s response to stress. HPA dysregulation can be characterized in part by continued activation of stress response systems and the hypersecretion of glucocorticoids like cortisol (Berens et al. 2017; McEwen 1998). During pregnancy, HPA dysregulation can lead to an over-exposure of glucocorticoids during fetal development, which in turn is associated with placental dysregulation (Nugent and Bale 2015), low birthweight and preterm delivery (Duthie and Reynolds 2013). The protective effect of social support may likewise be working through HPA activity through reducing glucocorticoid secretion. One study found pregnant women with low social support to secrete higher levels of cortisol in response to distress than those with more social support (Giesbrecht et al. 2013). Thus, where ACEs may increase fetal vulnerability due to maternal HPA dysregulation, social support during pregnancy may provide some buffer from cortisol exposure, which could promote healthy fetal growth. Future work should consider such biologic mechanisms explicitly.

This study has some limitations. First, the sample size was small. Though we implemented a sound modeling approach and distinct patterning in the associations was observed, we encourage future work to replicate this study among larger samples. Use of larger samples could also facilitate examination of these associations among population subgroups (e.g., younger/older mothers, racial/ethnic minorities). Also, information was not available on the specific physiologic pathways through which ACEs and social support affect fetal growth. These limitations notwithstanding, this study also has several strengths. It is among the first to consider ACEs in relation to fetal growth and risk mitigation by social support during pregnancy. We used a multimodal prospective design that included gold standard measures of social support and ACEs alongside anthropomorphic measures of fetal growth. Moreover, we rigorously controlled for confounding by including several demographic, maternal health, dietary, delivery, and infant characteristics in the multivariate models.

Evidence is accumulating that maternal ACEs contributes to poor birth outcomes. Our study adds to this evidence base and also demonstrated that social support can provide some buffer from the deleterious effects of ACEs. The American College of Obstetricians and Gynecologists (ACOG)

recently published a committee opinion report on the importance of the social determinants of health for reproductive outcomes and recommended screening and documenting experiences of adversity in clinical practice (ACOG 2018). This study underscores ACOG's recommendations and highlights the importance of ACEs and social support for maternal and infant health in particular. The public health impact of this research is significant as ACEs are highly prevalent in the population and social support is modifiable. Programs designed to promote factors like belonging social support and tangible aid may not only improve women's health, but promote infant health as well.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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