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Exploring Emotion Regulation and Social Support as Moderators of the Relationship between Sleep Disturbance and High Cortisol Levels in Cancer Survivors

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Abstract

Stress is a constant, ongoing occurrence in our lives, and research has given us further understanding of the health implications it has. Cortisol has been explored as a biomarker of stress, and high levels of it can lead to further health problems. Cancer is a life-changing disease and can have varying impacts on one's emotional and physical health. Cancer diagnosis and treatment is a stressful experience, and stress is known to impact other aspects of health, such as sleep. The importance of sleep quality on our proper bodily functioning is well known. Given how essential sleep is to our health, a disruption in sleep may also be connected to stress levels, which also may impact our health. There are many different potential moderators that may influence the relationship between stress and sleep. Two moderators explored in this study are emotion regulation and social support. We studied cancer survivors, due to the particular challenges they experience during and after treatment.. This study sought to examine the moderating strength of emotion regulation and social support on the relationship between cortisol levels and sleep disturbance in cancer survivors. In this study, 576 participants who had been diagnosed with breast, prostate, or colorectal cancer completed questionnaires over five time points, over the course of a year, reporting psychosocial resources, coping, and multiple domains of wellbeing. Participants also provided hair and nail samples for cortisol measurements. Results did not show a relationship between cortisol and sleep disturbance. Results did not show that social support or emotion regulation were significant moderators of the relationship between cortisol and sleep disturbance in cancer survivors. Results did show that emotion regulation and social support were independently associated with sleep disturbance. The study showed that there are important factors related to cancer survivors' health and well-being.

Stress and Cortisol as Physiological Measure of Stress

As our world has gotten more fast-paced and technology-driven, we've continued to explore stress and its varying impacts. Lazarus and Folkman (1984) defined psychological stress as " a relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being" (p. 21). It is well known that chronic stress can have negative outcomes in terms of our overall health (Yaribeygi et al., 2017). One of the mechanisms through which stress affects health is through physiological changes modulated by different hormones. The primary stress hormone, cortisol, plays an important role in the body's physical response to stress. Cortisol functions to increase sugars in the bloodstream as well as its use in the brain. It also suppresses nonessential functions. This shifted focus from nonessential bodily functions to pure survival functions is commonly referred to as the "fight-or-flight" response (Thau et al., 2022). Consistently high levels of cortisol can lead to many negative health effects including digestive problems, a suppressed immune system, and even heart disease (Yaribeygi et al., 2017).

Given cortisol's crucial role in our body's stress response, it has been explored and utilized as a biomarker of stress in previous studies (Liu & Doan, 2019). Newer methods for measuring cortisol include hair and nail cortisol, which represent an accumulation of cortisol over the course of multiple months, allowing for proper assessment of *chronic* stress (Liu & Doan, 2019). An increase in hair cortisol concentrations has been shown to coincide with increases in psychological and physical stressors. In a study exploring unemployment and financial strain as chronic stressors, hair cortisol and psychological stress were measured in individuals who had been unemployed for 1 year. It was found that hair cortisol analysis was a

powerful tool in measuring chronic stress due to a psychological stressor (Dettenborn 2010). Psychological stressors may include anything from daily hassles to major life events and trauma (Wester & van Rossum, 2015). Given the negative impact of stress/cortisol on wellbeing, many different factors can influence stress directly, and further exploration may lead to better understanding of stress and promote better stress management. One such factor shown to be affected by stress is sleep quality.

Sleep Quality and Physiological Impacts

Sleep quality is critical to proper bodily and overall functioning. Functions of sleep include energy conservation, brain waste clearance, essential maintenance, and preparation of immune responses to help fight disease (Zielinski 2016). These functions have lasting effects on physiological and behavioral outcomes, which directly affect quality of life, productivity, and overall health. Poor sleep quality can heavily influence our bodies and our lives on a daily basis. Long term effects of sleep loss have been associated with increased risk of diabetes, obesity, depression, heart attack, and stroke (Eaker et al., 1992; Qureshi et al., 1997; Schwartz et al., 1998; Newman et al., 2000; Ayas et al., 2003; et al., 2005; Bradley et al., 2005; Caples et al., 2005). There are also lifestyle impacts of sleep loss, including lack of productivity, decrease in work performance, variation in mood, and loss of connection with friends and family (Colten et al., 2006). According to a survey completed by adults through the American Psychological Association, a majority don't believe that they get enough quality sleep. According to the same survey, only 20% of adults report that the quality of their sleep is very good or excellent (APA).

Literature suggests that exposure to stressful events may impair normal sleep function (Bastien, Vallieres, & Morin, 2004; Friedman, Brooks, Bliwise, Yesavage, & Wicks, 1995; Hall et al., 2000, 2007, 2008; Healey et al., 1981; LeBlanc et al., 2009; Mezick et al., 2009; Morin et

al., 2003; Pillai, Roth, Mullins, & Drake, 2013). Stressors may prevent one from physically and emotionally resting, and with their body in constant overdrive, may lead to trouble falling and staying asleep (Kalmbach et al., 2018). Given the well-documented connection between stress and sleep, it is worth exploring the connection between cortisol, a biomarker of stress, and sleep. Cortisol is one of the products of the hypothalamic-pituitary-adrenal (HPA) axis. A study of xxx found that overactivation of the HPA axis may lead to sleep fragmentation and shortened sleep time (Buckley & Schatzberg, 2005). These authors also noted that in return, sleep disturbance may further impact proper cortisol release leading to further dysfunction of the HPA axis through a feedback mechanism (Buckley & Schatzberg, 2005). Due to the significance of our sleep cycle and its role in our bodily processes, a disruption may lead to a variety of dysfunctionality in our bodies. It would be beneficial to further study factors that may modify the relationship between stress and sleep.

Cancer Survivorship, Cortisol, and Sleep Disturbance

A population that may be uniquely impacted by poor sleep and elevated cortisol levels are cancer survivors. Cancer survivors make up a large portion of the population. As of January 2022, it is estimated that there are 18.1 million cancer survivors in the United States (National Cancer Institute). The number of cancer survivors will continue to grow due to the increase of the aging population (Irwin et al., 2013). Cancer can be a life-changing and life-threatening disease. Thus, being diagnosed with cancer itself can be considered a significant life stressor. Not only can cancer launch severe attacks on a patient's body, but the treatment itself can have similar lasting physical and emotional impacts. Cancer often requires aggressive treatment to beat it or to extend life as much as possible. Cancer patients have been shown to have elevated cortisol levels compared to healthy controls (Van Der Pompe et al., 1996). Cancer survivors

undergo a particular set of challenges during and after their treatment, which may be impacted by stress. One of those challenges is sleep disturbance, which may exacerbate the already-existing health issues and stress present in cancer survivors. Even before treatment, cancer patients have reported sleep disturbance, which continues through survivorship (Irwin et al., 2013). Cancer survivors' trouble sleeping has been linked to the many lasting consequences of cancer and chemotherapy. These include physical tolls like pain and fatigue, along with emotional tolls leading to anxiety, depression, and intrusive thoughts that lead to sleep disruptions (Strollo et al., 2020). In a study focused on breast cancer patients, higher cortisol levels at night were associated with poor sleep quality (Sephton et al., 2000). This raises the question of the relationship between stress (measured by cortisol) and sleep in cancer survivors, and what factors moderate the relationship.

Potential Moderators Influencing the Impact of Cortisol on Sleep Disturbance

As discussed, chronic stress can have a negative effect on one's physiology. On the other end, how we react to stressors can also influence the risk of those negative health effects. There are different strategies and factors that can help someone process and cope with their stress. Emotion regulation and social support status are two possible factors that play a role in one's stress response. According to the APA, emotion regulation is defined as "the ability of an individual to modulate an emotion or set of emotions" (American Psychological Association). Emotion regulation may include incorporating a period of buffering between the initial feeling of an emotion and one's reaction to the emotion. Emotion regulation may involve behaviors like reflecting on a situation, controlling impulsive reactions, or focusing on positives rather than negatives (Psychology Today). One's ability to regulate their emotions may directly impact their ability to cope with stress and therefore impact cortisol levels as well. An activation of the

hypothalamic-pituitary-adrenal (HPA) axis, and the release of its product, cortisol, may mark the relationship between stress and emotion regulation (Zimmermann & Stansbury 2004). The HPA axis can be activated by stress, and if emotion regulation plays a role in the level of stress, there may be a link between cortisol level and emotion regulation.

Social support can be defined as a "network of family, friends, neighbors, and community members that is available in times of need to give psychological, physical, and financial help" (National Cancer Institute). Low levels of social support have been associated with increased morbidity and mortality, while high levels of social support have been shown to buffer the effects of illness (Ozbay et al., 2007). In previous studies, low social support has been associated with heightened stress reactivity, indicated through elevated heart rate and increased blood pressure. Having a tighter-knit social support network may lower stress levels and improve one's ability to react to and cope with stress.

There has been much discussion regarding the connection between sleep and emotion. Poor sleep may lead to adverse mood effects and those effects influence one's ability to sleep, leading to a cycle of lack of sleep and irritability (Vandekerckhove & Wang 2018). Considering the previously discussed importance of sleep, emotion regulation, and social support, this relationship has been found to be bidirectional. Previous studies have found that a lack of sleep may be related to enhanced negative emotion reactivity as well as adverse effects on emotional functioning (Citation). Therefore, emotion regulation has been found to play a modulating role between stress and sleep (Vandekerckhove & Wang 2018).

Social support may heavily influence one's sleep, and therefore likely moderates the relationship between stress and sleep. Previous studies have found that higher levels of perceived social support predict better sleep quality (Nomura, Yamaoka, Nakao, & Yano, 2010; Troxel,

Robles, Hall, & Buysse, 2007). It has been discussed that, through an evolutionary context, social support may provide a safe environment for one to sleep, where they feel protected enough to rest (Dahl & El-Sheikh, 2007; Troxel, Buysse, Hall, & Matthews, 2009).

Taken together, the purpose of the present study is to examine the connection between emotion regulation, social support, and stress in a cancer survivor sample.

Thesis objectives and aims

This present study aims to examine whether emotion regulation and social support moderate the connection between sleep and cortisol in cancer survivors. Through this study, we focused on the following questions:

1. Is there a correlation between sleep disturbance and (hair and nail) cortisol concentrations?
2. How does the level of emotion regulation play a role in the relationship between sleep quality and cortisol levels in cancer survivors? Our hypothesis is that higher levels of difficulties with emotion regulation in cancer survivors predict a stronger relationship between sleep disturbance and cortisol level.
3. How does the level of social support play a role in the relationship between sleep quality and cortisol levels in cancer survivors? Our hypothesis is that lower levels of social support in cancer survivors predicts a stronger relationship between sleep disturbance and cortisol level.

Methods

Participants

Participants were recruited from Yale-New Haven Hospital in between 2019-2022. 576 patients were recruited, and this present study reports 569 people that reported over 5 time points. The Y.UCAN Cancer Survivorship study was conducted over the course of five years. This study specifically focuses on the results from timepoints one and two.

Procedures

In order to be eligible, participants must have been diagnosed with breast, prostate, or colorectal cancer stages 1 to 3. They must have been between the ages of 18-80 when diagnosed, and within four months of the end of the primary treatment. At time point one, participants were asked to fill out baseline questionnaires, and questionnaires at the rest of the time points. The self-report questionnaires contained measures of psychosocial resources, coping, and multiple domains of well-being. These questionnaires were mailed or administered through an online survey. Along with the questionnaires, participants (if able to), were asked to provide hair and nail samples by mail, with their returned filled out questionnaires. The main study procedures have been described elsewhere (Park et al., 2021)

Measures and Materials

Demographics

Participants reported their age, gender, race, ethnicity, income, and education level.

Hair and Nail Cortisol

Cortisol samples collected via hair and nail samples were provided by the participants. For nail samples participants were asked to cut approximately 2 mm from all five fingers on both

hands, and put the clippings in the aluminum bag provided to be sent back. For hair samples, participants were asked to cut 3 cm in length, and place the hair in the aluminum bag to be sent back. The samples were sent out to a collaborating lab for processing.

Sleep Impairment Scale

To measure sleep impairment, the PROMIS Sleep-Related Impairment scale was used (Yu et al., 2011). Participants rated statements such as, "I had trouble staying asleep" on a scale of 1 (not at all) to 5 (very much). One item was reverse coded. Higher sum scores indicated greater sleep impairment.

Difficulties in Emotion Regulation Scale

To measure Emotion Regulation, the Difficulties in Emotion Regulation Scale (DERS) was used (Kaufman et al., 2015). The 18-items (e.g., "When I'm upset, I acknowledge my emotions") were rated from 1 (almost never) to 5 (almost always). These items were then reverse-coded, therefore higher sum scores indicated greater difficulty with emotion regulation.

Social Support Scale

To measure social support, the Medical Outcomes Study Social Support Survey was used. The survey consisted of four separate social support subscales and overall functional social support index (Sherboune & Stewart 1991). A higher overall score indicated greater social support.

Data Analysis

We first used SPSS Version 29 to run basic study descriptives of means and standard deviations. We then ran basic correlations between the study variables. Next, we used the PROCESS macro (Hayes) to conduct the moderation analyses, to see if social support and emotion regulation moderate the relationship between sleep impairment and cortisol levels. The models were run a second time to control for covariates including age, gender, race, and use of steroid medications that may impact cortisol values. The results did not substantially change therefore results are presented without the covariates included in the models. The cortisol values required preliminary analysis. The values were skewed, so we first removed extreme outliers, which were any values over 1,000 pg/mg. Next, after checking for normality of the distribution we found that the hair and nail cortisol distributions were significantly skewed, and thus cortisol values were winsorized and log-transformed.

Results

Participant Characteristics

The mean age of the participants in the present study was 59 years old (*SD*=11.5). The majority 83.9%) racially identified as White, 63.4% as female, and 77.8% identified as not Hispanic/Latino. All reported participant demographics are presented in Table 1.

Descriptive Statistics:

Winsorized, log-transformed hair cortisol concentration values for time point one and timepoint two were 1.65, and 1.69 respectively. These values are lower than those found in a study of adults ages 18-70 (Binz et al., 2017), where the median hair cortisol concentration was

5.8 pg/mg. Nail cortisol concentration values for time point one and two were 1.44 and 1.47, respectively. The means and standard deviations of the cortisol values can be found in Table 2. Emotion regulation was M=34.19 (SD=10.59) for time point one, and M = 33.12 (SD=10.36) for time point two. Social support was M = 80.33 (SD=21.1) for time point one, and M = 80.04 (SD=20.21) for time point two. The normed sleep disturbance values were M = 52.34 (SD=9.8) for time point one, and M = 51.61 (SD=9.66) for time point two. Descriptive statistics can be found in Table 2.

Aim 1: Correlation between Sleep Impairment and Cortisol

Overall, the bivariate relationship between nail cortisol level and sleep impairment was not statistically significant, (r = 0.023, p = 0.679), nor was the relationship between hair cortisol level and sleep impairment (r = -0.005, p = 0.94). We utilized values from time point one for cortisol values since we were investigating its role as a predictor. We utilized values from time point two for sleep disturbance, since we were investigating sleep disturbance as the outcome. All correlations can be seen in Table 3.

Aim 2: Emotion Regulation as a Moderator in the Relationship between Cortisol and Sleep Impairment

Results showed that greater difficulty in emotion regulation is positively associated with more sleep impairment, when controlling for the impact of hair cortisol (B = 0.35, SE = 0.057, p < .01). The interaction between hair cortisol and emotion regulation was not a significant predictor of sleep (p = 0.98). Hair cortisol was not a significant predictor of sleep (p = 0.93.) Results also showed that greater difficulty in emotion regulation is positively associated with

more sleep impairment, when controlling for the impact of nail cortisol (B = 0.37, SE = 0.05, $p < .01$). The interaction between nail cortisol and emotion regulation was not a significant predictor of sleep ($p = 0.335$).

Aim 3: Social Support as a Moderator in Relationship between Cortisol and Sleep Impairment

Results showed that greater social support predicted less sleep impairment, when controlling for the impact of hair cortisol (B = -3.03, SE= 0.71, $p < .01$). The interaction between hair cortisol and social support did not significantly predict sleep ($p = 0.79$). Hair cortisol is not a significant predictor of sleep ($p = 0.94$). Results also showed that greater social support predicted less sleep impairment, when controlling for the impact of nail cortisol (B = -2.66, SE = 0.69, $p < .01$). Nail cortisol is not a significant predictor of sleep ($p = 0.538$). The interaction between nail cortisol and social support was not a significant predictor of sleep ($p = 0.287$).

Discussion

In this study, we sought to explore the particular challenges cancer survivors experience post-treatment, and how those challenges influence different parts of their emotional and physical wellbeing. We focused on understanding how sleep quality and physiological measures of stress vary in cancer survivors, and what potential factors influence the relationship between the two. We looked at levels of social support and emotion regulation as moderators of the relationship between cortisol and sleep disturbance.

The first aim of the study was to determine if there was an association between cortisol levels and sleep disturbance in a sample of cancer patients who recently or are currently engaged

in active treatment. Results showed that there was not a significant bivariate relationship between nail cortisol and sleep disturbance nor between hair cortisol and sleep disturbance. Our study does not support the idea that physiological biomarkers of stress impair normal sleep function, therefore we do not observe a correlation between high cortisol levels and sleep disturbance. Previous literature has shown that stressors may prevent one from getting quality sleep for a general population. (Kalmbach et al., 2018). Previous studies have also shown the connection between sleep and stress in cancer patients, where high cortisol levels were associated with poor sleep quality (Sephton et al., 2000). A possible reason why our study may not be seeing the same link between stress and sleep is due to hair and nail samples being a newer method for measuring cortisol. In addition to this method being relatively new, hair and nail cortisol represent an accumulation of cortisol over the course of just a couple of months, which may not be a long enough timeframe to measure chronic stress (Liu & Doan, 2019). Another possible reason our study didn't see a link between stress and sleep is due to the many factors that may influence cortisol values. These factors may include hair treatments, products, steroid creams, steroid medications, and hair exposure to chlorine. These factors may have led to variation in our cortisol values, leading us to not see the connection between physiological stress and sleep disturbance.

The second aim of the study was to examine how the level of emotion regulation plays a role in the relationship between sleep quality and cortisol levels in cancer survivors. Our hypothesis was that higher levels of difficulties with emotion regulation in cancer survivors predicts a stronger relationship between sleep disturbance and cortisol level. Results showed that the interaction between cortisol (hair & nail) and emotion regulation were not significant predictors of sleep. However, results did show that greater difficulty with emotion regulation was

positively associated with greater sleep disturbance,when controlling for the impact of hair and nail cortisol. Although emotion regulation may not play a moderating role between sleep impairment and cortisol, this study highlights the relationship between one's sleep quality and one's ability to control emotions. This is consistent with literature indicating that lack of sleep may be related to negative emotion reactivity (Cluydts 2003). The results of this study point to the ongoing cycle of poor sleep and irritability, in that poor sleep may lead to negative mood effects and those effects influence one's sleep quality.

The third aim of the study was to explore how social support plays a role in the relationship between sleep quality and cortisol levels in cancer survivors. Our hypothesis was that lower levels of social support predicts a stronger relationship between sleep disturbance and cortisol level. Results showed that the interaction between cortisol (hair & nail) and social support was not a significant predictor of sleep. However, results did show that greater social support was negatively correlated with sleep impairment, when controlling for the impact of both hair and nail cortisol. Although social support may not play a moderating role between sleep impairment and cortisol, study findings highlight a relationship between one's sleep quality, and the level of one's social support network. This finding is consistent with literature showing that higher levels of perceived social support predict better sleep quality (Nomura, Yamaoka, Nakao, & Yano, 2010;Troxel, Robles, Hall, & Buysse, 2007). Our results build upon this finding in relation to cancer survivors. Given the physical and emotional challenges cancer survivors undergo, social support may help them feel less alone, and isolated. Being surrounded by friends and family may help cancer survivors feel safe and protected, allowing them to rest peacefully at night.

This study is not without its limitations. A main limitation in this study is the generalizability of our sample. We are not able to generalize the results to the general population, due to the lack of diversity in our sample. Participants in the sample were predominantly White (83.9%), in the middle to upper class, with an average income of $110,670. Depending on socioeconomic barriers people face, cancer survivors may undergo different stressors as well as have varying levels of emotion regulation and social support. In future research it may be beneficial to perform this study with a sample that comes from various socioeconomic backgrounds. Another limitation regarding our sample was the types of cancer being limited to prostate, breast, and colorectal. This limits the generalizability of the results to all cancer survivors. According to the National Cancer Institute prostate, breast, and colorectal cancer are among the top ten types of cancer diagnosed in the U.S., although lung and skin cancer are just as prevalent (National Cancer Institute). If this study was conducted again in the future, it would be beneficial to include participants with a wider range of cancers, especially those who had skin and lung cancer.

Despite these limitations, this study offers important understanding of how levels of social support and emotion regulation may impact cancer survivors' sleep quality, which may have a direct impact on cortisol levels.

Conclusion

This study aimed to explore different factors that may moderate the relationship between sleep disturbance and cortisol levels in cancer survivors. Although emotion regulation and social support weren't found to be significant moderators, they were both independently associated with sleep disturbance. This study showed how greater difficulty in emotion regulation, and

lower levels of social support are each associated with greater sleep disturbance. This highlights the importance of having the ability to regulate one's emotions and being surrounded by friends and family during cancer treatment and early survivorship, as they both influence sleep, which is essential for other proper bodily functions. It's important for cancer survivors to prioritize getting quality sleep, as poor sleep may enhance existing health issues they may already be suffering from. Further research on this topic and other potential moderators, may have clinical implications regarding strategies and support systems cancer survivors may utilize to have a happier, and healthier life post-treatment.

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Figure and Tables

Table 1

Demographic Characteristics of Participants

Demographic Variable	*M* (SD)	N	%
Gender			
Female		365	63.4
Male		204	35.4
Age	59.24 (11.48)		
Race			
White		478	83.9
Black		40	7
Asian		7	1.2
American Indian		4	0.7
Multiracial		8	1.5
Not Reported		32	5.6
Ethnicity			
Hispanic or Latino		30	5.2
Not Hispanic or Latino		448	77.8
Not reported		32	5.6
Income	110,670 (305,333)		
Education			
No formal education		1	0.2
Grade School		8	1.4
High school graduate		11.3	12
Some college or associate degree		135	23.4
Bachelor's Degree		153	26.6
Graduate or professional degree		17	3
Masters Degree		122	21.2
Doctoral degree or professional degree		35	6.1
Prefer not to answer		4	0.7

Table 2

Descriptive Statistics

Measures	*M* (SD) T1	*M* (SD) T2	Range (T1)	Range (T2)
Hair Cortisol	15.53 (27.70)	17.19 (31.09)	0.11-115.62	0.10-128.05
Nail Cortisol	38.47 (95.21)	19.26 (36.66)	0.055-391.84	0.41-140.37
Emotion Regulation	34.18 (10.59)	33.12 (10.36)	18-82.00	18-75.00
Social Support	80.33 (21.07)	80.04 (20.2)	0.00-100.00	1.32-100.00
Sleep Disturbance	52.35 (9.80)	51.61 (9.66)	28.90-76.50	29.90 - 76.50

Note: Cortisol values are winsorized; Cortisol values are represented as pg/mg; Sleep disturbance is normed

Table 3

Bivariate Correlations

		Emotion Regulation	Sleep Disturbance	Nail Cortisol Concentration (pg/mg)	Hair Cortisol Concentration (pg/mg)	Social Support
Emotion Regulation	**Pearson Correlation**	1	.366**	0.002	-0.037	-0.269**
	Significance (2-tailed)		<0.001	0.968	0.509	<0.001
Sleep Disturbance	**Pearson Correlation**	0.366**	1	0.023	-0.005	-0.206**
	Significance (2-tailed)	<0.001		0.679	0.94	<0.001
Nail Cortisol Concentration (pg/mg)	**Pearson Correlation**	0.002	0.023	1	0.547**	0.017
	Significance (2-tailed)	0.968	0.679		<0.001	0.738
Hair Cortisol Concentration (pg/mg)	**Pearson Correlation**	-0.037	-0.005	0.547**	1	0.048
	Significance (2-tailed)	0.509	0.94	<0.001		0.399
Social Support	**Pearson Correlation**	-0.269**	-0.206	0.017	0.048	1
	Significance (2-tailed)	<0.001	<0.001	0.738	0.399	

*p < 0.05, **p < 0.01

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