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Exposure to Secondhand Smoke during Pregnancy and Neonatal-Related Outcomes

Alireza Valizadeh[1], Zahra Akbarian-rad[2], Mojtaba Qanbari Qalehsari[3], Ali Zabihi[4], Seyedeh Roghayeh Jafarian-amiri[5*], Parvin Aziznejadroshan[6], Rahim Akrami[7]

1.Student Research Committee, Babol University of Medical Sciences, Babol, Iran
2.Department of Pediatrics, School of Medicine, Non-Communicable Pediatric Disease Research Center Health Research Institute Amirkola Hospital Babol University of Medical Sciences, Babol, Iran
3.Department of Medical and Surgical Nursing, School of Nursing and Midwifery, Babol University of Medical Sciences, Babol, Iran
4.Social Determinants of Health Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran
5.Nursing Research Center, Babol University of Medical Sciences, Babol, Iran
6.Amirkola Children's Non-Communicable Disease Research Center, Health Research Center, Babol University of Medical Sciences, Babol, Iran
7.School of Health, Mashad University of Medical Sciences, Mashad, Iran

ABSTRACT

Background: Fetal and neonatal health is of particular importance in pregnant women. Secondhand smoke (SHS) can jeopardize the health of the mother, fetus, and neonate. The present study was conducted to determine the relationship between exposure to secondhand smoke during pregnancy and neonatal-related outcomes.
Methods: This retrospective cohort study was conducted in 2022 on 270 mother-newborn pairs through convenience sampling in two equal groups (n=135), including exposure and non-exposure to SHS at Rohani Hospital, Babol, Children's Hospital, Amirkola, and Imam Ali Hospital, Amol. In order to collect the data, a checklist including the demographic characteristics, medical variables, questions related to the exposure of mothers to cigarette smoke, the neonatal outcomes questionnaire, and the SNAPPE-II scale were used. Data analysis was performed using STATA statistical software (version 17), and the significance level of all tests was considered less than 0.05.
Results: The mean age of mothers was 28.30±5.83 years, and 61% of births were by cesarean section. The SNAPPE-II score was 8.23±5.29 in the non-exposure group and 20.68±13.53 in the exposure group (P=0.005). The prevalence of neonates with a birth weight of less than 2500gr was higher in mothers exposed to SHS (P=0.033). Considering confounding variables, the neonates in the non-exposure group were, on average, 1.46 cm taller than those in the exposure group (P=0.005). Exposure to smoking increases the risk of premature birth by 1.65 times (P=0.032).
Conclusion: Exposure of pregnant mothers to SHS is associated with adverse neonatal outcomes. Therefore, it is recommended to train families to avoid exposure to cigarette smoke, especially during pregnancy, and also for health centers to pay special attention to this matter in the care of pregnant mothers.

Keywords: Neonates, NICU, Pregnant woman, Smoke

Introduction

The smoking habit exists among different social groups in developing and developed countries, with a rate of 50% and 35%, respectively (1). Tobacco use has caused various health problems worldwide. The World Health Organization (WHO) has estimated that approximately 6 million people die annually from smoking and 890,000 from exposure to Secondhand smoke (SHS) (2). More than 80% of smokers in developing countries are challenged

* *Corresponding author*: Seyedeh Roghayeh Jafarian-amiri, Nursing Research Center, Babol University of Medical Sciences, Babol, Iran. Email: jafarianamiri@gmail.com

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with this issue (3). Those who inhale other people's cigarette smoke are called non-voluntary smokers, passive smokers, environmental smokers, or second-hand smokers (4).

There are growing concerns about the potential reproductive health effects and pregnancy outcomes of SHS exposure. Although exposure to SHS is preventable, it remains prevalent (5). The majority of SHS is in the form of side stream smoke produced from the lighted end of a cigarette, while mainstream smoke is exhaled by active smokers (6). Mainstream and sidestream smoke that contains thousands of compounds, many of which are harmful to humans, is produced at different temperatures and oxygen conditions, and harmful compounds vary in proportions between the two types of smoke (7, 8). For instance, side stream smoke contains more CO, less CO_2, and larger amounts of combustion products formed by nitrosation and amination than mainstream smoke (7).

Although the prevalence of English pregnant women who smoke is less than 11%, the number of pregnant women exposed to SHS is much higher (9), equal to 22.5% (10). Smoking prevalence among Iranians has been reported to be 12%, with 23.4% among men and 1.4% among women (11). In Iran, exposure to SHS at home is 57.5%, which is more than that in the workplace (49.2%) (12).

There are approximately 4,000 chemicals in SHS, many of which are known to be carcinogenic. If the mother is exposed to SHS during pregnancy, the mother's and child's health is at risk. The adverse effects of smoking on birth outcomes are not caused by the direct use of cigarettes by the mother. Mother's exposure to SHS is associated with complications, such as birth weight loss, height reduction, and head circumference reduction (13). These issues cannot be clearly identified for individuals (14). Other complications of exposure to SHS in pregnant women include premature delivery, premature rupture of membranes (PROM), increased probability of cesarean section, probability of decreased fetal growth, delay in intrauterine growth, low birth weight, fetal distress, sudden infant death syndrome, and increased follicular fluid levels. Studies have shown that a high rate of exposure to SHS at home was seen in people with low or moderate income (15).

Various studies have confirmed the relationship between exposure to SHS and spontaneous abortion. Other studies have shown that the consumption of more than 10 cigarettes by the father per day cannot increase the risk of spontaneous abortion in mothers exposed to secondhand smoke (16, 17). Stillbirth and increased fetal and neonate mortality are other important consequences of smoking (18,19). The analysis of various articles shows a 13% increase in the risk of genetic disorders among fetuses exposed to SHS. However, limited research confirms that mothers' exposure to SHS used by the father causes congenital heart disorder (20, 21).

According to the studies, exposure to SHS is important since the risks that this phenomenon poses to the fetus and mother, an increase in treatment costs, the resulting consequences, and the increase in the workload of nurses in neonatal intensive care units (NICU) are significant. A search in the available databases showed that no reliable study had been conducted on the consequences of SHS in premature neonates hospitalized in NICUs. Therefore, the present study was conducted to determine the relationship between exposure to SHS during pregnancy and neonatal-related outcomes.

Methods

This retrospective cohort study was conducted in 2022 with the participation of 270 mother-newborn pairs who met the inclusion criteria and were selected through convenience sampling and assigned into two equal groups (n=135), namely exposure to SHS and non-exposure to SHS at Rohani Hospital, Babol, Children's Hospital, Amirkola, and Imam Ali Hospital, Amol, after obtaining permission from the Ethics Committee.

In the present study, infants' head circumference, birth weight, birth length, first-minute Apgar, fifth-minute Apgar, gestational age, and neonatal jaundice were the study outcomes. According to a study by Gulpa et al. in 2015, the birth of a premature neonate (one of the most important outcomes of the study) among mothers not exposed to SHS was 20%, with an odds ratio of 2.2 (22). Therefore, considering power=80% and alpha error=5%, the minimum sample size for two-sided hypothesis testing was estimated to be 135 in each group (23). Moreover, according to the above formula, the samples included 135 mother-neonate pairs assigned into two equal groups of SHS and non-SHS.

The researcher attended the NICU of the three hospitals above and selected all newly admitted neonates during the first 12 hours of admission to the ward and stabilization of their condition if they met the inclusion criteria. After providing the necessary explanations to the parents (father or mother) regarding the study objectives and implementation and obtaining initial consent, he evaluated the infants based on the Score for Neonatal Acute Physiology with Perinatal Extension-II (SNAPPE-II) tool and recorded the findings in the relevant checklist. Then, at the first opportunity of the neonates' mothers' presence in the ward, he requested those who had the characteristics of the study subjects and were willing to participate in the study to fill out and sign the consent form after providing the additional explanations about the study objectives and method. In this study, the convenience sampling method was used, and the mothers under study were divided into two groups.

The SHS group included mothers whose neonates were hospitalized in the NICU and did not smoke cigarettes or hookah; however, they were exposed to SHS (cigarettes or hookah). The non-SHS group included mothers whose neonates were hospitalized in the NICU, were not smokers, did not use hookah, and were not exposed to secondhand cigarette smoke.

Exposure time is one of the indirect measures used to evaluate exposure to SHS. There is no standardized cut-off time for exposure to SHS in previous research, based on which the time has been identified as 5.5 hours. On the other hand, the WHO has defined SHS as those exposed to SHS for 1 hour or more in 5 days. Therefore, after reviewing all the evidence, the minimum exposure cut-off was decided to be 1 hour every 5 days (24).

Inclusion criteria for the SHS group included non-smoker mothers over 18 years of age with a history of exposure to cigarette or hookah smoke, singleton birth, and neonates being admitted to the NICU after birth.

Inclusion criteria for the non-SHS group included non-smoker mothers over 18 years of age exposed to cigarette or hookah smoke, who had a singleton delivery, and whose neonate was admitted to the NICU.

Exclusion criteria for both groups included women with a BMI above 30, a self-reported history of Cardio-Pulmonary-Renal disorders, HIV, or pregnancy complications due to anemia and Intrauterine Growth Restriction (IUGR) (25), being a smoker, alcoholic, or addicted to other drugs, having neonates requiring non-NICU care, admitted to the intensive care unit after 48 hours of hospitalization, died or discharged in less than 24 hours or needing no ABG upon admission with an unknown Apgar, and suffering from genetic disorders at birth. Confounding factors (type of delivery, number of children, mother's age, place of residence, economic status, and parent's education level) were adjusted in two groups.

The data collection tools included the following:

A: A checklist including the demographic characteristics, medical variables, and questions related to the exposure of mother to cigarette smoke, including mother's gestational age, father's age, fertility records and history, number of times exposed to cigarette or hookah smoke per day, history of smoking cigarette or hookah by the husband during pregnancy, place of exposure to cigarette or hookah smoke (home, workplace, or public places), source of cigarette or hookah smoke (husband, relatives, colleagues), medical records and pregnancy complications (self-reported), and economic status.

B: Neonatal outcomes questionnaire, including newborn head circumference, birth weight, birth length, first-minute Apgar, fifth-minute Apgar, gestational age, neonatal jaundice, and hypoglycemia.

C: SNAPPE-II scoring tool: The SNAPPE-II scale is used to evaluate the mortality and deterioration of infants admitted to the NICU after birth. The Score for Neonatal Acute Physiology (SNAP) was used by Richardson in 1993 for all neonates to determine their mortality and morbidity. In 1998, Richardson solved the difficulty of assessing patients with SNAP II. He facilitated its use by reducing the number of items to six and considering the neonates admitted during the first 12 hours in the intensive care unit to minimize the effects of initial treatments. Other variables, such as birth weight, Apgar score, and gestational age were also added to SNAP II; consequently, a broader and stronger scale called SNAPPE II was created based on physiological and clinical factors (26). This scale evaluates the first 12 hours of admission after the stabilization of the neonate. For instance, a non-invasive assessment of arterial blood pressure based on mmHg was performed using a right-size Sphygmomanometer cuff on the neonate's left or right hand.

The neonate's body temperature was measured through an axillary thermometer placed in the neonate's axillary for 3 minutes. Serum pH level and FiO_2/PaO_2 ratio were measured by arterial blood gas analysis. Moreover, all seizure types in neonates were included in this scale. Birth weight was measured without clothes using a digital scale, and urine output was measured in ml/kg/h using a neonate urine bag or a diaper weighing. The 12-week ultrasound was used to measure the gestational age. Lubchenco's intrauterine growth chart was used as the small-for-gestational-age classification for birth weight less than the 10th percentile for gestational age. The score range of this tool is between 0 and 162. The higher the score, the higher the probability of mortality and complications related to disorders (24). The average score of SNAPPE II among deceased neonates was 45.72±18.68, which is higher, compared to live neonates with a score of 21.04±15.418 (26). In the study by Dalili et al., the sensitivity and specificity of this tool were 84.44% and 79.05%, respectively (24). In another study, its sensitivity and specificity in predicting mortality were 76.9% and 87.1%, respectively (26).

Since sampling began in the NICU, we talked to the mothers in this unit, and if they agreed to participate in the study, their medical history was taken in the mothers' room in that ward or the women's ward if the mother was hospitalized there. The checklist was completed by the researcher.

Statistical analyses

STATA statistical software (version 17) was used to analyze the data. Patients' individual and clinical data were described using descriptive measures, such as frequency, percentage, mean, and standard deviation with statistical Fisher's exact test and Wilcoxon rank-sum test. For the outcome examined in this two-mode qualitative study, first, in order to determine the relationship between each variable under investigation and the outcome, Simple Logistic Regression was used, and the variables with a significance level of less than 0.2 in the univariate analysis entered into the Multiple Logistic Regression model (27). Finally, the effect of the main independent variable (exposure to SHS) was evaluated through the stepwise-backward method and controlling confounders and the adjusted odds ratio was reported. For quantitative outcomes, the adjusted beta index was calculated and reported using the Multiple Linear Regression model using the above method. The significance level of all tests was considered less than 0.05.

Ethical approval

Ethical approval for this study was obtained from the Research Ethics Committee of the Babol University of Medical Sciences (IR.MUBABOL.HRI.REC.1400.225). Written informed consent/ informed assent was obtained from the parents of the neonates.

Results

In this study, the mean age of mothers was 28.30±5.83 years, and approximately, 61% of births were by cesarean section. The SNAPPE-II score was 8.23±5.29 in the non-exposure and 20.68±13.53 in the exposure groups (P=0.005) (Table 1). Examining SNAPPE-II parameters

Table 1. Demographic and clinical features of the study subjects in the exposure and non-exposure to the SHS

Variables		Non-SHS-exposed mothers (n=135)	SHS-exposed mothers (n=135)	Total (n=270)	P-value
		n (%)	n (%)	n (%)	
Mother's age (years) Mean, SD		27.54±5.67	29.05± 5.91	28.30±5.83	0.003
Father's age (years) Mean, SD		31.65±5.64	33.35±5.93	32.50±5.84	0.016
SNAPPE-Ⅱ score		8.23±5.29	20.68±13.53	16.24±9.41	0.005 Wilcoxon rank-sum test
Head circumference		34.31±3.59	34.11±2.29	34.21±3.01	0.579
Length		49.53±3.70	47.78±4.76	48.65±4.35	0.001
Birth weight (gr)		3011.06±756.55	2954.57±823.81	2982.82±789.93	0.558
Delivery type	Cesarean	76 (57)	87 (65)	163 (61)	0.166
	Vaginal delivery	57 (43)	46 (35)	103 (39)	
Mother's education level	Illiterate	0 (0)	2 (1)	2 (1)	Fisher 0.016
	High school	8 (6)	20 (15)	28 (10)	
	Diploma	50 (37)	33 (24)	83 (31)	
	College education	77 (57)	80 (60)	157 (58)	
Father's education level	Illiterate	1 (1)	3 (2)	4 (2)	Fisher 0.035
	High school	21 (16)	33 (26)	54 (21)	
	Diploma	40 (31)	20 (15)	60 (23)	
	College education	66 (52)	73 (57)	139 (54)	
Residency place	Urban	105 (78)	88 (65)	193 (71)	0.002
	Rural	30 (22)	47 (35)	77 (29)	

Table 1. Continued

Economic status	Poor	2 (1)	11 (8)	13 (5)	Fisher 0.026
	Average	60 (44)	51 (38)	111 (42)	
	Good	72 (53)	68 (51)	140 (52)	
	Excellent	1 (1)	4 (3)	5 (2)	
Pregnancy	Wanted	124 (92)	117 (87)	241 (90)	0.223
	Unwanted	11 (18)	17 (13)	28 (10)	
Comorbidities (diseases)					
Diabetes	No	121 (90)	104 (77)	225 (83)	0.006
	Yes	14 (10)	31 (23)	45 (17)	
Thyroid disease	No	93 (69)	90 (67)	183 (68)	0.696
	Yes	42 (31)	45 (33)	87 (32)	
Hypertension	No	124 (92)	103 (76)	227 (84)	<0.001
	Yes	11 (8)	32 (24)	43 (16)	
Heart disease	No	130 (99)	132 (98)	262 (99)	Fisher 0.722
	Yes	5 (1)	3 (2)	8 (1)	
Depression	No	126 (93)	122 (90)	248 (92)	0.374
	Yes	9 (7)	13 (10)	22 (8)	

showed that the prevalence of neonates born with a weight of less than 2500gr was higher in mothers exposed to SHS (P=0.033). The Apgar score in the non-exposure to the SHS group was significantly higher than the exposure to the SHS group (P=0.006). This difference in some other parameters of SNAPPE II was also significant, which is presented in Table 2. By controlling confounding variables, the SNAPPE-II score was 4.36 points higher in the SHS

Table 2. SNAPPE-II parameters of the study subjects according to SHS and non-SHS

Variables		Non- SHS (Non-exposed Group) N=135	SHS (Exposed Group) N=135	Total patients N=270	P-value
		n (%)	n (%)	n (%)	
Mean blood pressure (mm Hg)	>30	115 (100)	128 (95)	243 (97)	0.016 Fisher
	20-29	0 (0)	7 (5)	7 (3)	
Lowest temperature (°C)	>35.6	129 (99)	132 (99)	261 (99)	> 0.999 f
	35-35.6	1 (1)	2 (1)	3 (1)	
FiO2/PaO2 Ratio	>2.49	98 (77)	75 (57)	173 (66)	0.002
	1-1.49	27 (21)	56 (42)	83 (32)	
	0.3-0.99	3 (2)	2 (1)	5 (2)	
Lowest serum pH	>7.20	121 (94)	105 (79)	226 (86)	<0.001
	7.10-1.19	8 (6)	27 (20)	35 (13)	
	<7.10	0 (0)	1 (1)	1 (1)	
Multiple seizures	Yes	3 (2)	10 (65)	13 (5)	0.084 Fisher
	No	128 (98)	123 (35)	251 (95)	
Urine Output (ml/kg/hr)	>1	91 (70)	84 (63)	175 (66)	0.082
	0.1-0.9	39 (30)	45 (34)	84 (32)	
	<0.1	0 (0)	5 (4)	5 (52)	
Apgar Score	>7	121 (92)	109 (81)	230 (86)	0.006
	<7	10 (8)	26 (19)	36 (14)	
Birth weight (gr)	>2500	111 (83)	93 (69)	204 (76)	0.033
	1500-2500	18 (13)	34 (25)	52(19)	
	<1500	6 (4)	8 (3)	14 (5)	
Small for gestational age	>p3	126 (98)	118 (87)	244 (92)	0.002 Fisher
	<p3	3 (2)	17 (13)	20 (8)	

>p3: Less than the third percentile, <p3: More than the third percentile

Table 3. Association between SHS with anthropometric indices and SNAPPE-II score: Multiple linear Regressions (Backward models)

Outcome	Adjusted β	95% CI	P-value
SNAPPE- II score	4.36[a]	0.99, 7.73	0.011
Head circumference	0.56[b]	- 0.21, 1.33	0.158
Weight	- 142.29[c]	- 346.95, 62.36	0.172
Length	- 1.46[d]	- 2.47, -0.45	0.005

a: adjusted for pregnancy, father's education level, hypertension
b: adjusted for father's education level, hypertension, delivery type
c: adjusted for mother's age, delivery type, mother's education level, father's education level, residency place, economic status, delivery type, hypertension, diabetes
d: adjusted for economic status, delivery type, father's education level

group,ncompared to the non-exposure to SHS group (P=0.011). Considering confounding variables, the birth length of neonates in the non-exposure to the SHS group was, on average, 1.46 cm taller than the exposure to the SHS group (P=0.005) (Table 3). Exposure to smoking increases the risk of premature birth by 1.65 times (Table 4).

Table 4. Association between SHS [a] with neonatal-related outcomes: Multiple logistic Regressions (Backward models)

Outcome	Adjusted OR	(95% CI)	P-value
Preterm delivery	1.65[b]	1.20, 2.28	0.032
PROM	1.16[c]	0.66, 2.03	0.588

a: SHS is compared to non-SHS
b: OR adjusted for father's age, delivery type, residency place, economic status, diabetes, hypertension
c: OR adjusted for father's age, delivery type, father's education level

Discussion

This study investigated the relationship between SHS during pregnancy and neonatal outcomes. The mean score of SNAPPE II in the present study was 16.24. This score in the group of infants of mothers not exposed to SHS was, on average, 4.36 points lower than the group of infants of mothers exposed to SHS. It can be concluded that the risk of mortality is lower in infants of non-SHS mothers who had a lower SNAPPE II score than those in the SHS group.

The age of mothers exposed to SHS was higher, compared to the other group. Moreover, the prevalence of mothers exposed to SHS in urban areas was higher than that in rural areas. In other studies, the results were similar to the findings of the present study (28, 29). It is important that these variables were considered confounding variables in the statistical analysis, and also, the mothers in our study had a uniform social and economic background. As a result, families' economic and social status could not influence the final analysis.

In our study, pregnant mothers exposed to SHS suffered significantly more from diabetes and hypertension than non-exposed mothers. However, in a study by Sobh E et al. (28), this relationship was not significant. Similar to the present study, other studies have mentioned the high risk of developing gestational diabetes in pregnant women exposed to cigarette smoke (30, 31). The high prevalence of gestational diabetes in pregnant women exposed to cigarette smoke is probably due to inflammatory responses, exudative stress, and insulin resistance (32). A systematic review and meta-analysis in 2022 reported that exposure to cigarette smoke has a protective effect on pregnancy hypertension (33). The effect of exposure to cigarette smoke on pregnancy hypertension requires a broader study with a larger sample size.

In this study, there was a significant relationship between mothers' exposure to SHS and the neonates' birth length; the neonates of SHS mothers had a shorter birth length (1.46 cm less). Furthermore, the findings of this study showed that the prevalence of neonates born with a weight of less than 2500gr by mothers exposed to SHS was significantly higher than that by mothers not exposed to SHS. Regarding the neonates' mean birth weight, there was no significant difference between the two groups. Neonates' short birth length and low birth weight have wide implications for public health, as short length and low birth weight are known risk factors (34). Therefore, avoiding SHS during pregnancy is one of the long-term ways to address short childhood length. Likewise, in other studies, neonates of SHS mothers were shorter and weighed less than those of non-SHS mothers (28, 35).

Furthermore, studies have shown that mothers exposed to SHS have more low-birth-weight neonates than mothers not exposed to SHS. However, no significant changes were observed in other anthropometric indices, such as length (13, 36). Carbon monoxide and nicotine inhaled through SHS appear to decrease placental blood flow, increase carboxyhemoglobin levels, and fetal hypoxia. In addition, vasoconstriction caused by nicotine may lead to fetal growth disorders (13, 37).

In this study, the Apgar score of neonates in the SHS group was significantly lower than that of non-SHS group neonates. Gupta et al. (36) showed similar results regarding Apgar score; however, in a study by Prince et al. (34), there was no correlation between exposure to SHS in mothers and neonates' Apgar scores.

Preterm neonates are at risk of acute perinatal complications and lifelong adverse health effects (38). This study showed that exposure to smoking increases the risk of premature birth by 1.65 times. Exposure to cigarette smoke seems to increase prostaglandin production and sensitivity to oxytocin, leading to increased contractions of uterine smooth muscles, and thus, the birth of a premature neonate (39). In the study by Delcroix-Gomez et al. (40), mothers exposed to SHS in the first and second trimesters of pregnancy had a lower risk of premature delivery than mothers exposed to SHS in the third trimester. In a systematic review, Parascandola et al. (41) showed that the risk of preterm birth in SHS mothers was 1.29 times higher than that in non-SHS mothers.

The findings of this study support the results of previous studies on the effects of SHS on some pregnancy outcomes (premature birth, as well as birth weight and height). One of the noteworthy points in the present study was the significant increase in the number of premature neonates weighing less than 2500gr in pregnant mothers exposed to SHS. Furthermore, using the SNAPPE II tool to estimate neonate mortality, which has not been used in similar studies, is another strength of this study. More vulnerability to bias due to the retrospective cohort study and the dishonesty of some mothers in reporting exposure to second-hand cigarette smoke due to social stigma were the limitations of this research.

Conclusion

Exposure to SHS has a negative effect on both mothers and their neonates, leading to an increase in the birth of premature and low-weight neonates and a decrease in the birth height. Moreover, due to the higher SNAPPE II score in neonates of mothers exposed to SHS, they are at an increased risk of mortality. Therefore, it is recommended that during regular prenatal care, mothers be emphasized not to be exposed to SHS.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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