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RESEARCH ARTICLE

MEDICAL STUDENTS' PERSPECTIVE ON THE TEACHINGPROCESS OF RADIOLOGY DURING AND AFTER THECOVID-19 PANDEMIC

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Abstract

Background: Over the last few years, radiology teaching and training have transformed from traditional lectures to early team-based clinical learning and case-based teaching.

Objectives: To assess the perspective of undergraduate medical students regarding radiology teaching during and after the coronavirus disease 2019 (COVID-19)pandemic.

Subjects and methods: A cross-sectional study was conducted among undergraduate medical students from third year to interns enrolled in Taif University for the academic year 2023-2024. An online, self-administered questionnaire was utilized for data collection. It contains 20 questions divided into three sections: I) general information and students' demographic data (4 questions); II) questions related to the student's teaching-learning experiences after the COVID-19 pandemic period (8 questions); and III) questions related to the student's teaching-learning experiences in the COVID-19 pandemic period (8 questions).

Results: A total of 204 students were included in the study. They were equally distributed according to their gender and almost equally distributed according to their academic year. The majority (86.3%) of them used tablets as the primary device for e-learning during and after the COVID-19 pandemic. Significant improvements were observed in the perspective of the participants regarding the quality of on-site radiology teaching ($p<0.001$), their performance in on-site radiologyteaching ($p=0.007$), and thoughts related to radiology teaching via e-learning ($p=0.023$) after the COVID-19 pandemic compared to it during the pandemic.

Conclusion: Medical students generally view radiology education positively after the pandemic. However, improvements in the structures and assessments of both online and onsite radiology teaching are needed. Interestingly, female students found e-learning and assessments more valuable, while older students appreciated the overall structure more.

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Introduction:-

Recent studies have insisted on the importance of radiology teaching for undergraduate medical students [1-3]. Over the last years, radiology teaching and training have transformed from traditional lectures to early team-based clinical learning and case-based teaching [4].

Like most other medical specialties, e-learning has proved to be a highly effective tool in radiology education and teaching, even before the pandemic of coronavirus disease 2019 (COVID-19) [2, 5].

Radiology e-learning has been extensively used in radiology teaching and training in the majority of European medical schools in recent years [6]. It has been observed that a combination of onsite face-to-face andonline e-learning successfully promoted students' knowledge and skills in basic and clinical radiology [7].

Undergraduate medical students often receive insufficient teaching input and are insufficiently trained in basic radiology [8, 9]. Basic and clinical radiology should be integrated into the medical curriculum due to the widespread use of medical images in clinical practice. This empowers students with image interpretation skills and the knowledge to seek expert radiological guidance when needed[7].

Several studies reported that even in specialized centers within the United States of America [10, 11] and the United Kingdom [8, 12], teaching radiology to undergraduate medical students is still very insufficient. This highlights the importance of radiology teaching and learning in undergraduate medical education, focusing on teaching image interpretation skills and appropriate ordering of investigations, which should be associated with prospective clinical practice [13]. The E-learning approach is limited by providing inadequate clinical experience to the students. Thus, there is a need for more modern teaching methods to train students in radiology better [14].

The COVID-19 pandemic has changed radiology teaching from traditional practical image interpretation to online tools that could enable proper teaching and even help students interact with image analysis. Therefore, it is necessary to understand the medical student's perspective on the teaching process of radiology during and after the COVID-19 pandemic to establish more effective teaching strategies in radiology.

The present study aims to assess the perspective of undergraduate medical students regarding the radiology teaching process during and after the COVID-19 pandemic in one of Saudi Arabia's universities, which, to the best of our knowledge, has not yet been reported.

Subjects and Methods:-

A cross-sectional design was conducted in Taif City, located in the western region of Saudi Arabia in Makkah Province, with an estimated population of 683,000 (2019 estimated census) [15]. Taif City has one government university (Taif University), including the College of Medicine. The study was conducted specifically at the College of Medicine, Taif University. The target population was undergraduate medical students enrolled in Taif University for the academic year 2023-2024, from third year to interns of both genders (approximately 430 students). Students who transferred from other colleges or universities during the COVID-19 pandemic, those with a gap in their studies during the pandemic, and those with insufficient attendance rates in the radiology lectures were excluded from the study.

An online self-administered questionnaire was utilized for data collection. It has been used previously in a study conducted among undergraduate medical students in Sao Paulo, Brazil [16]. Permission to use the questionnaire was asked through an e-mail communication with the corresponding author. The questionnaire contains 20 questions divided into three sections: I) General Information and students' demographic data (4 questions); II) questions related to the student's teaching-learning experiences after the Covid-19 pandemic period (8 questions); and III) questions related to the student's teaching-learning experiences in the Covid-19 pandemic period (8 questions). Students were informed about the study's purpose and benefits before giving their consent to participate and answer the questionnaire.

Assuming that 50% of undergraduate medical students perceived radiology teaching efficiently after COVID-19, setting the confidence interval of 95% and sample error of 5%, using the Raosoft sample size calculator program, the sample size calculation was 204 students, representing approximately 56% of the students. A stratified random

sampling equal proportion technique was adopted to select 102 female and 102 male students. Within each gender, the sample was equally distributed in different academic years (from third year to interns). A simple random technique was adopted to select students from each stratum from a list of students obtained from the college administration.

Statistical Package of Social Science SPSS, version 28, entered and analyzed the data. Descriptive statistics in the form of frequencies and percentages were calculated to summarize categorical data. Chi-squared/Fischer Exact and McNemar tests were used to evaluate the association between the determinants and the outcome variables and the difference in students` perception during and after the COVID-19 pandemic. Any p-value < 0.05 was considered statistically significant.

Results:-

A total of 204 students were included in the study. The majority of them (82.4%) were aged between 21 and 24 years. Equally distributed according to their gender and almost equally distributed according to their academic year. Most of them (44.1%) had grade average points (GPA) between 3 and <4, whereas 38.7% had GPAs between 4 and 5. Table 1

Most participants (86.3%) used tablets as the main device for e-learning during and after the COVID-19 pandemic, as seen in Figure 1.

Table 2 shows significant improvements in the perspective of the participants regarding the quality of on-site radiology teaching (p<0.001), their performance in on-site radiology (p=0.007), and thoughts related to radiology teaching via e-learning (p=0.023) after the COVID-19 pandemic compared to it during the pandemic.

Female students were more likely than males to consider radiology teaching via e-learning as very important (19.6% vs. 6.9%), p=0.023. Similarly, females were more likely than males to describe the assessment system of radiology teaching after the COVID-19 pandemic as very efficient (12.7% vs. 5.9%), p=0.005. Table 3

Older students (>24 years old) were more likely than younger students (21-24 years old) to describe the structure of the radiology teaching after the COVID-19 pandemic as very good (27.8% vs. 13.1%), p=0.024. Table 4

The medical students in the pre-clinical years were more likely than those in the clinical years to consider on-site radiology teaching as very good after the COVID-19 pandemic (25.9% vs. 7.6%), p=0.001. Table 5

Almost half of the students with a GPA of <4 (48.8%) described the quality of on-site radiology teaching after the Covid-19 pandemic as good, whereas 16.8% of them described it as very good compared to 29.1% and 12.7%, respectively, of students whose GPA was >4, p=0.020. Similarly, 44% of students with a GPA of <4 described the structure of the radiology teaching after the Covid-19 pandemic as good, whereas 14.4% of them described it as very good compared to 24.1% and 17.7%, respectively, of students whose GPA was >4, p=0.010. Students with a GPA of <4 were more likely than those with a GPA>4 to rate the assessment system of radiology teaching after the COVID-19 pandemic as very efficient (12% vs. 5.1%), p=0.018. Table 6

Discussion:-

Radiology educators usually face challenges in their job, including choosing adequate teaching time, financial constraints, allocating educational needs, professional development, and having instruments to assess teaching quality [17]. Therefore, depending on students' perceptions of learning experiences, it is considered a quality control tool to evaluate the practical aspect of the teaching process in practice [16].

Traditional onsite face-to-face academic teaching has been suspended during the COVID-19 pandemic in almost all worldwide medical schools to ensure social distancing and reduce the spread of COVID-19 infection among students and teaching staff [18-20]. Also, disruption observed in the radiology academic programs, with its short-term and long-term effects, is due to the COVID-19 pandemic [21, 22]. It has impacted the radiology teaching and practice of undergraduate medical students and postgraduate residents and fellows [1].

During the COVID-19 pandemic, e-teaching almost completely replaced traditional lectures and face-to-face teaching, which continued in many places after the pandemic [23]. The question now is whether online teaching and education will continue to be utilized in the long term or not.

The present study assessed the perspective of undergraduate medical students and interns regarding radiology teaching and compared it during and after the COVID-19pandemic and showed significant improvements in the perspective of the participants regarding the quality of on-site radiology teaching, their performance in on-site radiology teaching, and thoughts related to radiology teaching via e-learning after the COVID-19 pandemic compared to it during the pandemic.

In the current study, the majority of the students used tablets as the main device for e-learning during and after the COVID-19 pandemic. Recent studies showed that the preferred learning device depended on age. At the same time, older students were more likely to use desktops, and younger students tended to use tablets, notebooks, and smartphones, with no difference between all these technologies regarding their usefulness during online teaching activities [24].

Teaching in radiology should take more consideration from decision makers as it has been reported that radiology faculty members spent 72% of their time performing clinical work and only 19% on radiology teaching-related activities' furthermore, they spent more time in one-side teaching rather than interacting with students, which negatively impacts students` critical thinking skills [25].Therefore, there is a need to provide more active and encouraging interactions and assign more time for radiology teaching sessions.

This study revealed that older students (>24 years old) were more likely than younger students (21-24 years old) to rate the structure of the radiology lectures after the COVID-19 pandemic. However, pre-clinical medical students were more likely than those in clinical years to rate the on-site radiology teaching highly after the COVID-19 pandemic.These differences may be attributed to variations in academic experience, as older medical students experienced more practical activities in their clinical years than others. Additionally, pre-clinical years students were starting their clinical practice when they had to move to e-learning, which differed from their plans when they enrolled in the radiology lectures.

Also, the present study showed that female students were more likely than males to consider the importance of radiology teaching via e-learning and the efficiency of the assessment system of radiology teaching after the COVID-19 pandemic. This is not surprising as it has been documented previously that females were more engaged than males in online learning [26], and they have stronger self-regulation than males in online learning contexts [27].

It should be emphasized that the importance of e-teaching radiology is not because of the COVID-19 pandemic period, as previous pandemic studies showed a significant role of online teaching strategies as effective methods compared to traditional onsite face-to-face strategy [28]. Also, some others recommended a combination of online and face-to-face teaching [29].

To the best of our knowledge, The present study is the first to explore medical students` perception of radiology teaching changes due to the COVID-19 pandemic in one of Saudi Arabia's universities. However, some limitations exist, including being a single university study, which could impact the ability to generalize the findings over other universities in Saudi Arabia. Also, students' individual needs regarding their professional skills during the radiology training course were not investigated.

Conclusion:-

Overall, the perception of medical students regarding radiology teaching after the COVID-19 pandemic is promising. However, recommendations for improvement were identified in both the structure and assessment methods across traditional on-site and e-learning modalities. Female students were more likely than males to perceive the importance ofradiology teaching via e-learning and the effectiveness of the assessment system of radiology teaching after the COVID-19 pandemic. In contrast, older students were more likely than younger students to perceive the structure of the radiology teaching after the COVID-19 pandemic. These findings suggest the potential benefit of tailoring teaching approaches to consider student demographics and preferences for optimized learning outcomes.

Table 1:- Demographic characteristics of the participants (n=204).

Variables	Frequency	Percentage
Age in years		
21-24	168	82.4
>24	36	17.6
Gender		
Male	102	50.0
Female	102	50.0
Academic year		
3rd	44	21.6
4th	41	20.1
5th	38	18.6
6th	40	19.6
Intern	41	20.1
Grade point average (GPA)		
2.5-<3	35	17.2
3-<4	90	44.1
4-5	79	38.7

Table 2:- The perspective of undergraduate medical students regarding radiology teaching during and after the COVID-19 pandemic.

	During the pandemic	After the pandemic	p-value*
How do you rate the quality of on-site radiology teaching?			
Very bad	13 (6.4)	7 (3.4)	
Bad	17 (8.3)	8 (3.9)	
Moderate	88 (43.1)	74 (36.3)	
Good	70 (34.3)	84 (41.2)	
Very good	16 (7.8)	31 (15.2)	<0.001
How do you rate your performance in on-site radiology?			
Very bad	9 (4.4)	7 (3.4)	
Bad	14 (6.9)	17 (8.3)	
Moderate	98 (48.0)	82 (40.2)	
Good	66 (32.4)	61 (29.9)	
Very good	17 (8.3)	37 (18.1)	0.007
How do you rate the structure of radiologyteaching?			
Very bad	5 (2.5)	6 (2.9)	
Bad	12 (5.9)	11 (5.4)	
Moderate	93 (45.5)	81 (39.7)	
Good	72 (35.3)	74 (36.3)	
Very good	22 (10.8)	32 (15.7)	0.058
Have you experienced e-learning teaching?			
No			
Yes	35 (17.2)	29 (14.2)	
	169 (82.8)	175 (85.8)	0.286

What were your thoughts related to radiologyteaching via e-learning?			
Not important	4 (2.0)	11 (5.4)	
Of little importance	21 (10.3)	18 (8.8)	
Moderate	88 (43.1)	77 (37.7)	
Important	63 (30.9)	71 (34.8)	
Very important	28 (13.7)	27 (13.2)	0.023
How do you rate the assessment system of radiology teaching?			
Inefficient	10 (4.9)	12 (5.9)	
Of little efficiency	14 (6.9)	14 (6.9)	
Moderate	93 (45.5)	101 (49.5)	
Efficient	63 (30.9)	58 (28.4)	
Very efficient	24 (11.8)	19 (9.3)	0.067

*McNemar test

Table 3:- The perspective of undergraduate medical students regarding radiology teaching after the COVID-19 pandemic according to their gender.

	Males N=102 N (%)	**Females** N=102 N (%)	p-value*
How do you rate the quality of on-site radiology teaching?			
Very bad	4 (3.9)	3 (2.9)	
Bad	5 (4.9)	3 (2.9)	
Moderate	31 (30.4)	43 (42.3)	
Good	45 (44.1)	39 (38.2)	
Very good	17 (16.7)	14 (13.7)	0.508
How do you rate your performance in on-site radiology teaching?			
Very bad	4 (3.9)	3 (2.9)	
Bad	7 (6.9)	10 (9.8)	
Moderate	39 (38.2)	43 (42.2)	
Good	39 (38.2)	22 (21.6)	
Very good	13 (12.8)	24 (23.5)	0.064
How do you rate the structure of radiologyteaching?			
Very bad			
Bad	1 (1.0)	5 (4.9)	
Moderate	5 (4.9)	6 (5.9)	
Good	43 (42.2)	38 (37.3)	
Very good	38 (37.3)	36 (35.3)	
	15 (14.7)	17 (16.7)	0.518
Have you experienced e-learning teaching?			
No	12 (11.8)	17 (16.7)	
Yes	90 (88.2)	85 (83.3)	0.316
What were your thoughts related to radiologyteaching via e-learning?			
Not important	5 (4.9)	6 (5.9)	
Of little importance	7 (6.9)	11 (10.8)	
Moderate	39 (38.2)	38 (37.2)	
Important	44 (43.1)	27 (26.5)	
Very important	7 (6.9)	20 (19.6)	0.023

How do you rate the assessment system of radiology teaching?			
Inefficient	9 (8.8)	3 (2.9)	
Of little efficiency	9 (8.8)	5 (4.9)	
Moderate	41 (40.2)	60 (58.8)	
Efficient	37 (36.3)	21 (20.6)	
Very efficient	6 (5.9)	13 (12.7)	0.005

*Ch-squared test

Table 4:- The perspective of undergraduate medical students regarding radiology teaching after the COVID-19 pandemic according to their age.

	21-24 years N=168 N (%)	**>24 years** N=36 N (%)	p-value†
How do you rate the quality of on-site radiology teaching?			
Very bad	7 (4.2)	0 (0.0)	
Bad	8 (4.8)	0 (0.0)	
Moderate	58 (34.5)	16 (44.4)	
Good	68 (40.4)	16 (44.4)	
Very good	27 (16.1)	4 (11.2)	0.329
How do you rate your performance in on-site radiologyteaching?			
Very bad	7 (4.2)	0 (0.0)	
Bad	14 (8.3)	3 (8.3)	
Moderate	72 (42.9)	10 (27.8)	
Good	48 (28.6)	13 (36.1)	
Very good	27 (16.1)	10 (27.8)	0.201
How do you rate the structure of radiologyteaching?			
Very bad			
Bad	6 (3.6)	0 (0.0)	
Moderate	11 (6.5)	0 (0.0)	
Good	65 (38.7)	16 (44.4)	
Very good	64 (38.1)	10 (27.8)	
	22 (13.1)	10 (27.8)	0.024
Have you experienced e-learning teaching?			
No	26 (15.5)	3 (8.3)	
Yes	142 (84.5)	33 (91.7)	0.201*
What were your thoughts related to radiology teaching via e-learning?			
Not important	9 (5.4)	2 (5.6)	
Of little importance	15 (8.9)	3 (8.3)	
Moderate	70 (41.6)	7 (19.4)	
Important	52 (31.0)	19 (52.8)	
Very important	22 (13.1)	5 (13.9)	0.093
How do you rate the assessment system of the radiology teaching?			
Inefficient	10 (6.0)	2 (5.6)	
Of little efficiency	13 (7.7)	1 (2.8)	
Moderate	87 (51.8)	14 (38.9)	
Efficient	44 (26.2)	14 (38.9)	
Very efficient	14 (8.3)	5 (3.8)	0.316

†Chi-squared test *Fischer Exact test

Table 5:- The perspective of undergraduate medical students regarding radiology teaching after the COVID-19 pandemic according to their academic year.

	Pre-clinical N=85 N (%)	**Clinical** N=119 N (%)	p-value*
How do you rate the quality of on-site radiology teaching?			
Very bad	3 (3.5)	4 (3.4)	
Bad	6 (7.1)	2 (1.7)	
Moderate	26 (30.6)	48 (40.2)	
Good	28 (32.9)	56 (47.1)	
Very good	22 (25.9)	9 (7.6)	0.001
How do you rate your performance in on-site radiology teaching?			
Very bad	4 (4.7)	3 (2.5)	
Bad	7 (8.2)	10 (8.4)	
Moderate	29 (34.2)	53 (44.6)	
Good	24 (28.2)	37 (31.1)	
Very good	21 (24.7)	16 (13.4)	0.228
How do you rate the structure of the radiology teaching?			
Very bad	2 (2.4)	4 (3.4)	
Bad	3 (3.5)	8 (6.7)	
Moderate	34 (40.0)	47 (39.5)	
Good	26 (30.6)	48 (40.3)	
Very good	20 (23.5)	12 (10.1)	0.087
Have you experienced e-learning teaching?			
No	16 (18.8)	13 (10.9)	
Yes	69 (81.2)	106 (89.1)	0.111
What were your thoughts related to radiology via e-learning?			
Not important	3 (3.5)	8 (6.7)	
Of little importance	8 (9.4)	10 (8.4)	
Moderate	32 (37.6)	45 (37.8)	
Important	32 (37.6)	39 (32.8)	
Very important	10 (11.9)	17 (14.3)	0.814
How do you rate the assessment system of radiology teaching?			
Inefficient	4 (4.7)	8 (6.7)	
Of little efficiency	9 (10.6)	5 (4.2)	
Moderate	38 (44.7)	63 (52.9)	
Efficient	29 (34.1)	29 (24.4)	
Very efficient	5 (5.9)	14 (11.8)	0.113

*Chi-squared test

Table 6:- The perspective of undergraduate medical students regarding radiology teaching after the COVID-19 pandemic according to their grade average point (GAP).

	GPA <4 N=125 N (%)	**GPA ≥4** N=79 N (%)	p-value*
How do you rate the quality of on-site radiology teaching?			
Very bad	4 (3.2)	3 (3.8)	
Bad	4 (3.2)	4 (5.1)	
Moderate	35 (28.0)	39 (49.3)	
Good	61 (48.8)	23 (29.1)	
Very good	21 (16.8)	10 (12.7)	0.020
How do you rate your performance in on-site radiology teaching?			
Very bad	4 (3.2)	3 (3.8)	
Bad	8 (6.4)	9 (11.4)	
Moderate	48 (38.4)	34 (43.0)	
Good	42 (33.6)	19 (24.1)	
Very good	23 (18.4)	14 (17.7)	0.518
How do you rate the structure of the radiology teaching?			
Very bad	5 (4.0)	1 (1.3)	
Bad	8 (6.4)	3 (3.8)	
Moderate	39 (31.2)	42 (53.1)	
Good	55 (44.0)	19 (24.1)	
Very good	18 (14.4)	14 (17.7)	0.010
Have you experienced e-learning teaching?			
No	21 (16.8)	8 (10.1)	
Yes	104 (83.2)	71 (89.9)	0.184
What were your thoughts related to radiology via e-learning?			
Not important	9 (7.2)	2 (2.5)	
Of little importance	11 (8.8)	7 (8.9)	
Moderate	46 (36.8)	31 (39.2)	
Important	42 (33.6)	29 (36.7)	
Very important	17 (13.6)	10 (12.7)	0.699
How do you rate the assessment system of radiology teaching?			
Inefficient	5 (4.0)	7 (8.9)	
Of little efficiency	9 (7.2)	5 (6.3)	
Moderate	56 (44.8)	45 (57.0)	
Efficient	40 (32.0)	18 (22.8)	
Very efficient	15 (12.0)	4 (5.1)	0.018

*Chi-squared test

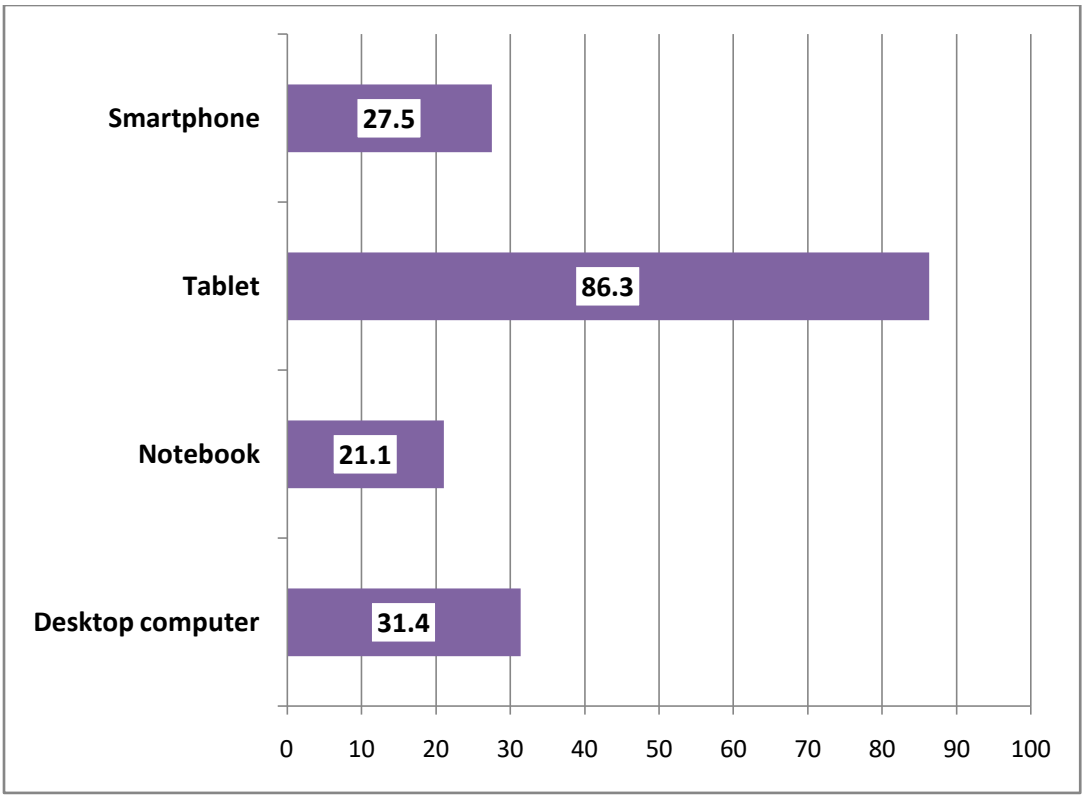

Figure 1:- Participants` main device for e-learning during and afterthe COVID-19 pandemic

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