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Is Health Care Support Associated with Better Educational Achievement in Sensorineural Hearing Impaired Students with Overlooked Recurrent Otitis Media?

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Abstract

Background: Otitis media is an important health care problem in school-age children. Moreover, the prevalence of allergic rhinitis, a major and common cause of otitis media, is increasing among children. Recurrent otitis media may occur without any noticeable symptoms and affect the auditory threshold (AT). Only a few decibles increase in hearing loss does not have the same effect on the hearing ability of individuals with different degrees of hearing loss. With this background in mind, in this study, we aimed to determine whether diagnosis and medical treatment of overlooked recurrent otitis media are associated with the educational achievement of students with sensorineural hearing impairment.

Methods: The present study with a pretest-posttest design was conducted on 30 students (aged 12 - 20 years) with bilateral sensorineural hearing impairment, AT above 30 dB HL in the better ear, and recurrent (2 episodes) middle ear infection over 9 months during 2012 - 2014. The participants were examined regularly and received medical treatment when indicated. The mean scores of total average, Persian literature (eg, reading, writing, and spelling), and mathematics were measured to assess the subjects' educational achievement.

Results: Based on the findings, the total average scores significantly changed from 16.2 to 17.2. Also, the students' Persian literature (from 16.8 to 18) and mathematics (from 13.8 to 16.7) scores were significantly improved. In addition, AT considerably decreased after the medical intervention (from 73 $\pm$ 14.7 to 56.3 $\pm$ 13.8 dB HL).

Conclusions: It seems that detection and treatment of overlooked middle ear infection in hearing impaired students, as part of comprehensive health care services, can improve their AT, diminish their hearing disabilities, and ameliorate their educational difficulties; consequently, provision of health care services is associated with better educational achievement.

Keywords: Otitis Media, Auditory Threshold, Educational Achievements, Sensorineural Hearing Loss, Comprehensive Health Care

1. Background

Hearing loss in school-age children is one of the major public health problems in developing countries (1). Two-thirds of hearing impaired patients live in developing countries, while around 50% of these cases can be prevented (2). According to the Classification of functioning, disability, and health by the world health organization (WHO), disabling hearing impairment is defined as permanent hearing loss with an auditory threshold (AT) above 30 dB in children under 15 years and AT above 40 dB in adults at frequencies of 0.5, 1, 2, and 4 kHz (3).

It is well recognized that hearing loss affects speech and language development, thereby leading to learning problems and poor academic achievement among children (4-6). Literacy development of hearing impaired children (HIC) is a major issue, influenced by various disciplines. Health, education, and social welfare sectors play pivotal roles in this area through secondary (early detection) and tertiary (timely interventions via integrated rehabilitation services) prevention (7). Moreover, individualized factors, such as severity of sensorineural hearing loss (the most important factor) and family support, considerably influence the patient's prognosis and differentiate HIC from their peers (8).

Another important health care problem in school-age children is otitis media (9). This type of infection is defined as "an inflamation of the middle ear without refrence to etiology or pathogenesis". Otitis media without effusion is a stage of middle ear inflamation in which "the mucosa of the middle ear is involved, but no effusion is present" (10).

On the other hand, allergic diseases such as allergic rhinitis are very common in children and show an increasing prevalence (11, 12). In fact, allergic rhinitis, an important etiological cause of otitis media in childhood, is known to aggravate the Eustachian tube dysfunction (13).

Otitis media in children affects different developmental domains and has been discussed from different viewpoints, including otology, pediatrics, speech, language, and educational/psychological aspects of growth in children (14). Otitis media (with or without effusion) with negative pressure in the middle ear is associated with additional conductive hearing loss (15). Considering the fact that hearing loss does not develop in a linear fashion, each 10 dB increase in hearing loss does not have the same effect on the hearing ability of individuals with normal hearing function or two different people with different degrees of hearing loss (15).

Speech perception, along with favorable speech conception (or speech and auditory skills), directly influences the reading comprehension skills and learning abilities of HIC (16). On the other hand, since children with severe hearing loss are not sensitive to changes in their hearing threshold, ear diseases may be easily overlooked. Therefore, few cases of conductive hearing loss, concomitant with severe to profound sensorineural hearing loss, have been reported in the medical literature (17).

Early detection and interventional treatment of hearing loss in newborns have been successful in Iran, and 80% of hearing impaired students attend regular schools (18); however, lack of a tracking system makes us alert about their educational achievement. In fact, the number of school-age children with hearing loss has been documented, whereas the percentage of graduated students and their graduation level are yet to be addressed.

Identification of the effect of overlooked ear diseases, specifically middle ear problems (influencing the hearing potential), on the educational achievement of HIC can help us determine the pitfalls and establish the role of public health care services in ameliorating the educational difficulties of these children; in addition, it may help raise the quality of life among HIC. With this background in mind, in this study, we aimed to determine whether free regular ear, nose, and throat (ENT) examination and medical treatment of otitis media (through usual medical procedures and treatments) are associated with the academic achievement of hearing impaired students in regular educational settings.

2. Methods

2.1. Participants

The present study with a pretest-posttest design was conducted on 30 bilateral sensorineural hearing impaired students (SNHIS) with recurrent otitis media, selected from 14 schools, using the following sample size formula ($\alpha = 5\%$, $\beta = 20\%$):

$$n = \frac{\left(z_{1-\frac{\alpha}{2}} + z_{1-\beta}\right)^2 \sigma_\delta^2}{\delta^2} + \frac{z_{1-\frac{\alpha}{2}}^2}{2} \quad (1)$$

The subjects were selected from a primary sample of 466 SNHIS with a low socioeconomic status. All the participants were registered in the deaf welfare clinic, affiliated to the welfare organization. The subjects were examined during the fall, winter, and spring of 2012 - 2014.

Among 200 students, who were examined in one session, 34 cases showed otitis media. A total of 266 students were checked 3 times during 3 seasons, among whom 80 cases showed signs of otitis media in 3 seasons. Since one of the inclusion criteria in this study was 2 episodes of infection during 3 seasons, 15 subjects were excluded from the study after evaluation, as only one episode of infection was detected during 3 seasons of evaluation. Therefore, 65 children were included in the study (23 cases were recorded to have type B tympanograms, and the rest were identified with type C tympanograms; negative pressure $\geq$ 300 mm H_2O).

Another inclusion criterion was use of two hearing aids during the study. Among 65 eligible students, 14 experienced hearing aid failure, which could be a confounding factor for their academic achievement; as a result, they were excluded from the study. Among the remaining 51 students, 21 cases were also eliminated, as they did not meet the third inclusion criterion (ie, bilateral otitis media) and had unilateral infections.

A total of 30 children were recruited in the study, based on the following inclusion criteria: (1) bilateral sensorineural hearing loss with an auditory threshold (AT) of > 30 dB HL in the better ear; (2) bilateral otitis media with or without effusion (or middle ears with negative pressure $\geq$ 300 mm H_2O) and 2 sessions of medical intervention per 9 months; (3) use of appropriate hearing aids in both ears; (4) similar educational settings such as regular schools; (5) Normal IQ; (6) no other disabilities; and (7) cooperation and participation in long-term monitoring of middle ear function and recording of educational performance.

Finally, 28 students remained in the study; however, 2 subjects quit school and were excluded from the research. The present study was carried out at Asma research and educational rehabilitation clinic and continued until October 2014.

2.2. Procedures

AT was evaluated via pure tone audiometry (PTA) at frequencies of 250, 500, 1000, 2000, and 4000 Hz. The auditory threshold shift (ATS) in the better ear was assessed, based on speech reception threshold (SRT) changes at 500, 1000, and 2000 Hz. Both PTA and SRT were determined by AD229 Audiometer (Interacoustics, Denmark). Also, the middle ears were assessed by otoscopy (Welch Allyn Model 22820) and screened objectively using impedance audiometry (Madsen AZ7, Denmark), also known as tympanometry.

The type of tympanograms was recorded as follows: type A (normal middle ear function), type B (with effusion), and type C (negative middle ear pressure and high negative pressure $\geq$ 300 mmH_2O). Medical interventions, such as wax removal, medical treatment of middle ear infection (mainly through prescription of antibiotics, eg, 8 mg/kg of cefixime or co-amoxiclav), and control of allergic rhinitis (mostly through topical corticosteroids, eg, 50 mcg of fluticasone propionate twice per day), were provided for each patient by the otolaryngologist when indicated.

All children received up to 2 years of free medical service through regular ENT examinations every 1 to 2 months. AT and ATS were expressed as dB HL before and after the medical intervention. During the intervention, in case of abnormal tympanogram (such as high negative middle ear pressure $\geq$ 300 mmH_2O) or type B tympanogram due to middle ear infection, the subject was carefully followed-up by the otolaryngologist and audiologist every week.

Tympanometry was carried out weekly during 3 - 6 weeks. When the tympanogram returned to type A after the medical intervention, PTA and SRT were recorded. Any changes in SRT before/after the medical intervention were compared and reported as additional conductive hearing loss or ATS (in dB HL). The primary outcome was the mean total average score (the average score of all study subjects during a school year), the secondary outcomes were the scores of mathematics and Persian literature (average scores of reading, writing, and spelling), and the tertiary outcome was the mean ATS.

The mean scores of mathematics and Persian literature were investigated and used to assess the students' educational achievement before and after the medical intervention during 2013 - 2014. In this study, the Iranian grading system (marks from 0 to 20) was employed to measure the educational achievement.

The ethics committee of the University of Social Welfare and Rehabilitation Sciences approved the present study (No., USWR.REC.1392.112). Also, informed consent forms were obtained from the parents.

2.3. Statistical Analysis

Continuous data are expressed as mean $\pm$ SD and analyzed using SPSS version 21. Non-parametric Wilcoxon test was used to determine the difference in the average of two dependent samples (before and after the intervention). Fisher's exact test was performed for determining the association between qualitative variables. Also, Mann-Whitney test was used to investigate the difference in educational performance between different age groups and subjects with different degrees of hearing loss. P value less than 0.05 was considered statistically significant.

3. Results

In the primary sample of 466 SNHIS, 200 were examined during one season, and 34 (17%) cases of middle ear problems were detected. In total, 266 students were examined 3 times during 3 seasons, among whom 80 (30%) cases had otitis media and 65 cases had middle ear infection with or without effusion (2 episodes during 9 months); therefore, they were included in the study. Nevertheless, 15 cases were eliminated from the study due to only one episode of infection during 3 seasons. Also, 14 children used one hearing aid and were consequently eliminated from the study. Among 51 children with middle ear infection and two hearing aids, 21 cases were excluded due to unilateral otitis media. Hence, 30 children with bilateral otitis media and AT above 30 dB HL in the better ear were selected; however, 2 cases quit school and were excluded from the analysis.

Ultimately, the study sample consisted of 28 SNHIS with the mean age of 15.5 $\pm$ 2.2 years (range: 12 - 20 years). In total, 15 children were 12 to 15 years old, while 13 cases were within the age range of 16 - 20 years. The study sample included 16 boys and 12 girls, attending educational settings similar to a regular school. The final visit by the otolaryngologist was in the past 6 - 12 months in 4 children. Also, in 12, 8, and 4 children, the final visit was within the past 1 - 2 years, 2 - 3 years, and $\geq$ 3 years, respectively. Most of the participants (24 cases) were visited by the otolaryngologist for more than a year, while only 4 (15%) children were examined for less than a year.

The degree of hearing loss in the subjects was as follows: 31 - 50 dB in 13 (46.4%) children, 51 - 70 dB in 13 (46.4%) children, and 71 - 90 dB in 2 (7%) children. AT was less than 50 dB HL in 13 children and over 50 dB HL in 15 (54%) students. The mean AT was 73 $\pm$ 14.7 (min: 40 dB HL, max: 90 dB HL) in the better ear before the medical intervention. The frequency of otitis media during 9 months was 2 episodes in 21 (75%) children, 3 episodes in 3 (10.7%) children, and more than 3 episodes in 4 (14.3%) cases. The participants' demographics are reported in Table 1.

Table 1. Demographic Characteristics of the Participants

Characteristics		Values[a]
Sex	Male	16 (57)
	Female	12 (43)
Age, y	12 - 20	28 (100)
	12 - 15	15 (54)
	16 - 20	13 (46)
Hearing threshold in the better ear, dB	< 50 (31 - 50)	13 (46)
	> 50 (51 - 70)	13 (46)
	71 - 90	2 (7)
SRT status before the intervention,dB HL	Min: 40, Max: 90	73 ± 14.7
Frequency of otitis media during 6 months, episodes	2	21 (75)
	3	3 (10.7)
	> 3	4 (14.3)
The final visit	In less than a year	4 (15)
	In more than a year	24 (85)

[a]Values are expressed as mean ± SD or No. (%).

3.1. The Effect of Medical Intervention on the Average Marks

The average marks significantly improved in the study sample and changed from 16.2 to 17.2 ($P < 0.0001$). General progress was observed, which seems to be associated with the provision of free and regular health care support (Table 2).

3.2. The Effect of Medical Intervention on the Students' Marks

Based on the findings, the students' Persian literature marks were improved; the mean scores significantly increased from 16.8 to 18 ($P = 0.004$). Also, math scores significantly increased, with a greater improvement, compared to Persian literature ($P < 0.0001$). The mean scores changed from 13.8 before the medical intervention to 16.7 after the intervention (Table 2). Progress was observed in the students' marks, which seems to be associated with the provision of free and regular health care support (Table 2).

3.3. The Effect of Medical Intervention on AT Improvement

AT significantly improved after the medical intervention. On the other hand, SRT significantly decreased from 73 ± 14.7 to 56.3 ± 13.8 dB HL after the medical intervention ($P < 0.0001$; Table 2).

3.4. The Relationship Between Age and Educational Performance

We also compared the marks between the two age groups (12 - 15 and 16 - 20 years old). We found that the scores before and after the intervention did not differ between the two age groups (Mann-Whitney test; Table 3).

3.5. The Relationship Between Different Degrees of Hearing Loss and Educational Performance

The scores were compared between two groups with different degrees of hearing loss (30 - 50 dB and 50 - 90 dB). The results showed that the scores before and after the intervention were not significantly different (Mann-Whitney test; Table 4).

4. Discussion

The present study aimed to assess the association between health care support (concerning the detection and treatment of overlooked recurrent otitis media) and academic achievement among SNHIS through regular otologic examination. We hypothesized that most episodes of otitis media remain disregarded due to unnoticeable minor signs and symptoms. Besides, loudness growth is nonlinear and the undetected increase in hearing loss (specifically at a hearing threshold above 30 dB) may majorly affect the hearing ability and learning process of SNHIS.

In the present study, we found a positive association between health care support) through regular ENT examination and medical intervention) and better educational achievement in the study sample. We can explain this finding in three parts:

Part 1: The increase in the total average marks after the medical intervention showed an improvement in the educational performance of students, most probably due to the treatment of mild conductive hearing loss through medical intervention. The current results were consistent with studies by Bess et al. (19) in 1998 and Khairi Md Daud et al. in 2010 (20), which highlighted the effect of even mild hearing loss on reduced educational performance of hearing impaired school-age children in comparison to their peers with a normal hearing function.

In the present study, we compared educational achievement in two different age groups (age range: 12 - 15 and 16 - 20 years), as well as two groups with different degrees of hearing loss (30 - 50 and 50 - 90 dB). The findings revealed that the marks were not significantly different between these groups; therefore, medical intervention could actually improve educational performance.

Otitis media affects the educational achievement of children in two ways. First, recurrent early childhood otitis media induces auditory processing deficits and considerably delays speech and language development, which is followed by reading disorders and learning problems (21, 22). Second, the increase in hearing loss, which was mentioned before and was the main interest of the present

Table 2. Comparison of the Average Variables Before and After the Intervention

Variables	Mean ± SD	Median	Min-Max	P Value
SRT				< 0.0001
Before	73 ± 14.7	80	40 - 90	
After	56.3 ± 13.8	57.5	30 - 80	
Literature scores				0.004
Before	16.8 ± 2.7	17	8 - 20	
After	18 ± 2	19	10 - 20	
Math scores				< 0.0001
Before	13.8 ± 3.9	14.4	7 - 19	
After	16.7 ± 2.5	16.9	12 - 20	
Total average				< 0.0001
Before	16.2 ± 1.9	16.6	12.5 - 19.1	
After	17.2 ± 1.9	17.4	13.4 - 19.5	

Table 3. Comparison of the Scores Between Two Age Groups[a]

Scores	Age Groups, y		P Value
	12 - 15 (n = 15)	16 - 20 (n = 13)	
Literature			
Before	17.47 ± 1.96	16.06 ± 3.26	0.254
After	18.47 ± 1.06	17.42 ± 2.72	0.555
Mathematics			
Before	13.20 ± 4.09	14.58 ± 3.66	0.636
After	16.67 ± 2.82	16.79 ± 2.23	0.928
Total average			
Before	16.58 ± 2.17	15.86 ± 1.61	0.294
After	17.42 ± 1.98	16.85 ± 1.77	0.316

[a]The Mann-Whitney test shows that the scores (before and after the intervention) are not significantly different between the two age groups (12 - 15 and 16 - 20 years).

Table 4. Comparison of the Scores Between Two Groups with Different Degrees of Hearing Loss[a]

Scores	Threshold Level Groups, db		P Value
	30 - 50 (n = 13)	50 - 90 (n = 15)	
Literature scores			
Before	16.38 ± 3.33	17.18 ± 2.03	0.650
After	17.38 ± 2.63	18.50 ± 1.21	0.294
Math scores			
Before	13.69 ± 3.95	13.97 ± 3.97	0.751
After	16.65 ± 2.49	16.78 ± 2.62	0.786
Total average			
Before	15.83 ± 2.29	16.61 ± 1.55	0.363
After	16.90 ± 2.06	1.38 ± 1.74	0.555

[a]The Mann-Whitney test shows that the scores (before and after the intervention) are not significantly different between the two threshold level groups (30 - 50 and 50 - 90 db).

study, is effective, as well. In the past, hearing impaired students attended special schools, whereas today, their presence in mainstream schools is highly advocated (23, 24). Therefore, these students should cope with their normal peers through residual hearing. This competition can be difficult for these students, and they need to be supported through eliminating the risk factors and enhancing their capabilities or assets.

Part B: In the present study, we also explored the students' educational achievement by assessing their average math scores with respect to improved residual hearing. The subjects showed better performance in mathematics, and the mean scores raised by 2.9 marks.

Part C: we found that the mean scores of Persian literature improved by 1.2 marks; the mean scores of mathematics were higher than literature scores. These results were consistent with the findings reported by Mukari et al. (25) and Traxler (26), who studied the educational performance of hard-of-hearing children. Their findings indicated that the subjects' language performance was weaker than their math skills.

Unfortunately, there is no standardized test to assess spoken language skills in Persian language; therefore, we cannot determine the relationship between these skills and different domains of educational performance. Many

researchers have revealed that SNHIS have major math problems. This problem seems to emerge from preschool concepts about mathematics (mainly due to impaired hearing), which may be related to later academic performance in these children (27). The impact of hearing loss on language and comprehensive reading skills has been discussed in the literature and its relation to solving math problems in deaf children has been elucidated (4, 28, 29).

Children with hearing impairment need extra time to process sounds or speech; therefore, they miss some information which can confuse them in abstracting the meaning of conversations. Besides, hearing loss does not develop in a linear fashion. In an ideal situation, one's actual hearing should be the same as his/her hearing potential. However, hearing is a very sophisticated task, and as Smeds and Leijion (2010) stated, "There is no simple one-to-one correspondence between loudness and intensity" (30). In fact, a mild change in the auditory input may interfere with actual hearing in hearing impaired students and influence their educational performance.

Additionally, in the present study, the mean ATS was 16.8 $\pm$ 6.8 dB in the better ear after medical treatment, which indicates an extra mild conductive hearing loss due to otitis media. The reported ATS (or decrease in AT) improved the hearing potential in the study sample after the medical intervention. This finding is in line with a previous study by Northern and Down, which showed that even -100 mm H_2O elevate hearing threshold. They also revealed an approximate 27 dB HL shift of AT in children with bilateral otitis media (15).

The present results are also consistent with previous research, which indicated the effect of otitis media as a fluctuation of AT in subjects (aged 6 - 21 years) with bilateral sensorineural hearing loss (9, 31). Also, similar findings were reported by Ozturk in 2005 and Egeli in 2003, who found that otitis media is an important health problem in schools for deaf children and can influence the degree and type of hearing loss in SNHIS (9, 32).

In addition, the present findings showed that most children (n = 24, 85%) had not been visited by an otolaryngologist for more than a year, and only 4 (15%) cases were examined within less than a year; this could imply that more children might suffer from symptomless or overlooked otitis media. This finding is in line with a study by Teel and Sade, which showed that fluctuating conductive hearing loss due to middle ear inflammation can appear, resolve, and reappear several times without any considerable signs or symptoms (33, 34). As a result, it is considered a risk factor for listening, communicating, and learning in hearing impaired students.

The mentioned finding is consistent with a study by Marschark in 2015, who emphasized on the analysis of social and academic outcomes of hearing impaired students in order to identify the assets and risk factors at individual, family, and school levels (35). In the present study, our main interest was to show that residual hearing in SNHIS is the most valuable individual asset; in fact, features which compromise the hearing ability are considered as the most serious risk factors. Overall, lack of a regular otologic examination for SNHIS in developing countries results in failure to detect common ear diseases, while these overlooked diseases can affect the students' residual hearing or individual assets and may be associated with reduced educational performance.

The current findings were also in agreement with a study by Olusanya, which implied that the full spectrum of hearing disability and rehabilitation needs of HIC, especially in developing countries, are unlikely to be properly addressed by the WHO criteria (36). Therefore, it can be suggested that in developing countries such as Iran, rehabilitation assessment of hearing impaired students is required with a community-based approach in order to identify the risk factors and enhance their assets or potentials.

Developed countries established integrated rehabilitation services through deaf education about 200 years earlier than developing countries (37). Deaf education in Iran began in 1924 by Jabbar Asgarzadeh (Baghcheban) with 3 deaf students in Tabriz. Deaf education was authorized in 1949 after 25 years of Baghcheban's continuous effort, and finally the first school for the deaf was established in 1957 in Tehran (38).

Currently, we need to consider and investigate the academic achievement of SNHIS from a general viewpoint in educational settings to determine the pitfalls and also focus on individuals with sensorineural hearing loss to identify the overlooked aspects in educational activities (eg, inappropriate hearing aids and recurrent ear diseases). Overall, policymakers in developing countries need to consider the outcomes of such studies for decision-making regarding the development of suitable strategies. It should be noted that the circumstances are completely different for SNHIS with a high socioeconomic status in Iran.

4.1. Conclusions

It seems that detection and treatment of overlooked otitis media in SNHIS, as part of comprehensive health care support, can improve their AT, diminish their hearing disabilities, and ameliorate their educational difficulties; consequently, health care support is associated with better educational achievement.

4.2. Strengths and Limitations

The present study had several limitations. First, although health cards in Iran cover approximately all chil-

dren in any part of the country and provide immunization and growth monitoring for children, they do not include other medical records. Since the sample of the present study had a low socioeconomic background, without a clear medical history or even regular ENT examination (also, no definite health management information system), we cannot make a clinical judgment about the effect of early childhood otitis media.

Another limitation of this study was lack of standardized assessment methods for investigating different dimensions of speech and language performance in Iran. Also, lack of a standard method for educational assessment was another limitation of this study. Therefore, we applied a pretest-posttest design to compare each case with itself and also to control the probable confounders.

Another shortcoming of the present study was with respect to hearing aids. The high cost of hearing aids in developing countries could impose some limitations during the course of the study; in fact, as mentioned before, this limitation resulted in the relatively small sample size of this study. Also, ENT examination and hearing evaluation 3 times during 3 seasons was very difficult, and only 266 out of 466 children could be evaluated 3 times in our study.

Finally, we lost 6.67% of the subjects in the follow-ups. Overall, we were faced with some problems which developed countries have already overcome. Therefore, we could not find any similar recent studies in the literature for comparison. There were also few studies in the literature regarding the effect of middle ear treatment on the educational achievement of SNHIS. Also, as mentioned earlier, studies in developing countries have not provided any information regarding AT changes and educational performance.

On the other hand, the strength of this study was the participants' strong adherence to the study and their cooperation with regular ENT examinations and hearing evaluations, which were conducted several times over the study period.

Based on the findings, the need for future ongoing integrated public health care and welfare support for SNHIS is strongly felt in developing countries. Overlooked recurrent middle ear infections or even dysfunctions are regarded as important factors, which affect the educational achievement of SNHIS. It is also necessary to perform long-term studies with a large sample size in order to confirm the findings.

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