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Effects of Psychological and Physical Factors and Morning-Evening Type on Occupational Accidents among the Workers of Porcelain Industry in Iran: Structural Equation Modeling

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Background & Aims of the Study: Nowadays, occupational accidents associated with severe harms for people and heavy economic and social loss are counted among the serious complications of the societies. Therefore, the present study aimed to investigate the relationship between stress, anxiety, fatigue, workload, morning-evening type, and occupational accidents among the workers of the porcelain industry in 2017 in Iran.

Materials and Methods: This cross-sectional study with a descriptive-analytical approach was performed in one of the porcelain factories of Iran. The samples were selected through simple random sampling method out of the study population consisting of 205 rotating- and day-shift workers and day-working individuals of the factory workforce. The study instruments included a researcher-made demographic questionnaire (for age, work experience, gender, marital status, work shift, and the number of accidents), Checklist Individual Strength (CIS) for assessing people fatigue, Epworth Sleepiness Scale, Morningness-Eveningness questionnaire (MEQ) developed by Horne and Ostberg. All the data were analyzed by Chi-square, Mann-Whitney, t-test, and structural equation using LISREL and SPSS software version 20.

Results: Our results showed that 62.2% and 3.8% of the workers were male and female, respectively. The mean and standard deviation of the age of the participants was 32.27±6.17 years. The mean work experience of the individuals was found to be 6.44±4.49 years. According to the findings of this study, 56.7% and 50.9% of the 108 people who had sleep apnea were rotating- and day-shift workers, respectively. The mean score of MEQ among all the participants was revealed as 45.15±4.94, which is categorized as intermediate. The personal ability score was obtained as 64.23±14.4 in day-shift people and 61.12±10.66 in rotating-shift individuals. Workload, stress, and sleeplessness were diagnosed as the factors of fatigue among all the workers ($P<0.05$).

Conclusion: According to the results of the present investigation, sleepiness, high workload, and stress are prevalent among the workforce of the porcelain industry. The mentioned factors significantly lead to fatigue. However, sleepiness was found to be significantly correlated with fatigue in people working a rotating shift.

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Background

Nowadays, occupational accidents associated with severe harms for people and heavy economic and social loss are counted among the serious complications of the societies (1). According to the estimation of the Workplace Safety and Health Council (WSH) of Singapore in 2017, 2.78 million deaths due to work occur annually throughout different countries, which is higher than the report of 2.33 million deaths in 2014. Asia has the leading share in this regard with two-third of work-related mortality cases of the world (2).

In general, the major cause of accidents and harms in work environments is unsafe conditions and acts. The behavior of a worker in the environment may reflect unsafe actions and unsafe conditions are attributed to the management practices and work environment (3).

The inherent factors of work as one of the three categories of unsafe conditions could directly play a role in generating workload (3). The workload is defined as the amount of work that should be completed by one or a group of workers or people in a time interval (4). According to the literature, the high workload has a direct relationship with accidents (5, 6), in addition to the indirect relationship through mediators, such as stress, fatigue, and reduced job satisfaction (4).

The physical-mental conditions of people, stressful factors, safety instructions, and safety culture can result in unsafe actions (7, 8). Therefore, numerous studies have evaluated the relationship between occupational accidents and the physical conditions of individuals, namely sleeplessness (9, 10), sleepiness (11), and fatigue (11, 12, 13). Bolghanabadi et al. demonstrated that rotating-shift working causes sleep disorder leading to the occurrence of accidents (14).

Leger et al. indicated in their investigation that the prevalence of sleeplessness is increasing in the world leading to an elevated risk of accidents at home, work, and driving. Nonetheless, occupational and domestic accidents related to sleeplessness are mostly neglected in the press.

Beurskeus et al. defined fatigue as “change in the mechanism of psychological control that balances task behaviors resulting from initial physical or mental efforts, which partly become laborious. Therefore, the individual is not sufficiently able for confronting the needs of a job in terms of mental function or is not able to face the demands unless they improve the mental effort and overcome the psychological resistance” (15). Fatigue can raise the risk of accidents by influencing sleeplessness, in addition to affecting the occurrence of accidents directly (9).

As mentioned above, alterations in the psychological conditions of people might cause accidents by generating unsafe actions. Various studies have investigated the relationship between stress and accidents (7, 13), as well as anxiety and accidents (16, 17).

Khandan et al. revealed a negative relationship between anxiety and accidents. In other words, a person with anxiety is more careful about errors and accidents (16). However, another study showed reported a positive relationship between anxiety and accidents and injuries in sports (17).

In another study, job-related stress was introduced as a type of psychological pressure due to the augmented demands of the work environment and the resultant pressure, which is intolerable for the individual (18). Knowledge and awareness in the work environment diminish following an increase in the level of stress and fatigue leading to unsafe behaviors and a high risk of accidents (13). The role of stress has been confirmed in 37% of the accidents and injuries in industries (7).

Sleeplessness, sleepiness, sleep disorders (19-22), anxiety (23, 24), and neuroticism (23, 25,

26) are related to circadian typology (as a personal characteristic) on one hand and with accidents on the other hand. Consequently, the aforementioned factors connect morning-evening and accidents on the two sides of a chain. In other words, these physical or psychological complications act as the mediator in this chain.

Morning- and evening-type individuals experience the highest level of awareness and agility at the beginning and end of the day, respectively (22). Delayed sleeping, sleeplessness, day sleepiness, and low sleep quality are more reported in evening-type people (20, 21). Juan et al. performed a study on adults with the mean age of 50.06 indicating a higher rate of anxiety symptoms in evening-type individuals, compared to morning-type people (24).

Moreover, neuroticism is another psychological disorder associated with circadian typology. Pourmazaherian et al. in a study noted the correlation between neuroticism and accidents (27). The findings concerning the correlation of circadian typology with neuroticism are controversial. Some studies revealed neuroticism to be related to eveningness typology (22), while Diaz-Morales reported this relationship with the morning type (26).

Therefore, this characteristic cannot be definitely attributed to one of the two types. Therefore, the importance of this chain shows that recruitment of people proportional to their characteristic may minimize the negative impacts of these types, such as recruiting evening-type individuals for night shift (19).

The mentioned physical and psychological complications and workload that originates from the inherent factors of work are of high prevalence in diverse industries. Furthermore, the direct and sometimes indirect relationship between each of these factors and accidents have been demonstrated in different studies. With this background in mind, the present study aimed to evaluate the correlation between stress, anxiety, fatigue, workload, chronotype, and occupational accidents among the workers of the porcelain industry in 2017.

Materials & Methods

This cross-sectional study with a descriptive-analytical approach was performed in one of the porcelain factories of Iran. The samples were selected through simple random sampling method out of the study population consisting of 205 rotating- and day-shift workers and day-working individuals of the factory workforce.

The exclusion criterion was having work experience of less than one year. The data regarding stress, anxiety, sleeplessness, and workload were collected through self-expression. The data collection tools entailed a researcher-made demographic questionnaire (for age, work experience, gender, marital status, work shift, and the number of accidents), Checklist Individual Strength (CIS) for assessing people fatigue, Epworth Sleepiness Scale (ESS), Morningness-Eveningness Questionnaire (MEQ) developed by Horne and Ostberg.

The multidimensional CIS has been designed to assess the diverse aspects of fatigue, including subjective fatigue, reduced motivation, diminished physical activity, and decreased concentration (27). This questionnaire encompasses 20 items with seven options ranging from yes to no and the seven scales in this spectrum are scored as 0-6. Therefore, the final score is in the range of 0-120 with a median of 60 (27, 28). Khandan et al. reported Cronbach's alpha of this questionnaire as 0.67 (28).

The ESS questionnaire contains eight questions that examine people's feeling of sleepiness in a variety of conditions. Each item is scored as 0-3 resulting in a total number of 0-24. This range is divided into three intervals of normal (0-10), median (10-12), and sleepy

(12-24) (29). The reliability of the ESS questionnaire was obtained as 0.78 by Labbafinejad et al. (29).

The MEQ survey is a self-expression tool for determining evening and morning types. This questionnaire has 19 questions concerning the times of sleeping and waking up, preferred times for physical activities, mental function, and agility after waking up. Each question has four responses and is scored based on the Likert scale.

Following scoring, the participants are categorized into five groups of circadian type, including definite morning (70-89), morning (59-69), intermediate (42-58), evening (31-41), and definite evening (16-30) types (30). Various studies have reported the reliability of this survey as acceptable (30, 31).

All the data were statistically analyzed using LISREL and SPSS software version 20. In order to compare the qualitative variables, namely age, marital status, education level, workload, accident, anxiety, and stress, the Chi-Square test was utilized.

In addition, the Mann-Whitney non-parametric test was applied for comparing the score of sleepiness based on the variables related to the work shift. The scores of MEQ and CIS were compared between the two groups by independent t-test parametric test. Furthermore, path analysis and structural equation were used for assessing the relationship of sleepiness, workload, stress, anxiety, and chronotype with the dependent variable of accidents separately in the two groups of rotating shift and day shift.

Results

In the present study, 205 questionnaires were delivered among the workers and 202 cases were finally analyzed. The reliability of the three questionnaires of CIS, ESS, and MEQ was obtained as 0.97, 0.71, and 0.83, respectively. Our results showed that 62.2% of the participants were men and 37.8% were women. The mean and SD of the age of the individuals was 32.27±6.17 years and the mean work experience of the people was 6.44±4.49 years.

Furthermore, the evaluation of the relationship between demographic and occupational factors with rotating-shift working indicated that most of the rotating-shift workers were male (Table 1). High and moderate workload has been found to be more frequent in people working day shifts, compared to rotating-shift workers and day-shift workers mostly reported a high workload (P=0.015). In terms of stress, 83.1% and 52.7% of the rotating- and day-shift workers were revealed to have stress, respectively.

Anxiety as another variable was reported in 80.9% of rotating-shift workers and 57.1% of day-shift workers. Moreover, 33% of the day-shift workers stated they had experience of the accident, while 10% of the rotating-shift workers had this experience. The mean accident score in the two groups of day- and rotating-shift work was 0.42±1.01 and 0.17±0.54, respectively.

In addition, we observed that the mean of ESS score was a little (0.13) higher among the rotating-shift workers than the workers of the day shift. However, the latter difference was not found to be significant (P=0.817). Considering the mean score of ESS, out of 108 subjects with sleep apnea, 56.7% were the rotating-shift worker and a lower percentage (50.9%) worked on day shifts.

Our findings demonstrated that the mean and SD of the morningness-eveningness scale for all the participants was 45.15±4.94, which is considered as an intermediate type. It was found that the day- and rotating-shift workers had the means of 45.31±4.84 and 44.94±5.08, respectively. It should be noted that 22.3% (n=112) of the day-shift workers and 24.4% (n=90) of the rotating-shift workers were intermediate type close to evening type. The

Table 1) Characteristics of rotating-shift workers and day-shift workers

Parameters	n (%)	Rotating-shift workers n=90 (44.6 %) n (%)	Day-shift workers n=112 (55.4 %) n (%)	P-value
Gender				
Male	125 (62.2)	79 (87.8)	46 (41.4%)	0[a]
Female	76 (37.8)	11 (12.2)	65 (58.6%)	
Marital status				
Single	29 (14.6)	9 (10.1%)	20 (18.2%)	0.109[a]
Married	170 (85.4)	80 (89.9%)	90 (81.8%)	
Educational level				
Diploma or lower	140 (69.7)	58 (65.2%)	82 (73.2%)	
Associate	36 (17.9)	24 (27%)	12 (10.7%)	0.013[a]
Bachelor	24 (11.9)	7 (7.9%)	17 (15.2%)	
Master and upper	1 (0.5)	0	1 (0.9%)	
Workload				
Very low	2 (1)	0	2 (1.8%)	
Low	4 (2)	0	4 (3.6%)	
Intermediate	70 (35.4)	25 (28.4%)	45 (40.9%)	0.015[a]
High	89 (44.9)	50 (56.8%)	39 (35.4%)	
Very high	33 (16.7)	13 (14.8%)	20 (18.2%)	
Stress				
Yes	133 (66.2)	74 (83.1%)	59 (52.7%)	0[a]
No	68 (33.8)	15 (16.9%)	53 (47.3%)	
Anxiety				
Yes	136 (67.7)	72 (80.9)	64 (57.1)	0[a]
No	65 (32.3)	17 (19.1)	48 (42.9)	
Accident				
Yes	40 (23)	10 (12%)	30 (33%)	0.001[a]
No	134 (77)	73 (88%)	61 (67%)	

ESS=Epworth Sleepiness Scale, MEQ=Morningness-eveningness Questionnaire, CIS=Checklist Individual Strength, a=Chi-Square test, P-value < 0.05

Table 2) Differences between sleepiness and fatigue scores and the state of morningness-eveningness in the two groups of rotating-shift workers and day-shift workers

Variables			Total	Rotating-shift workers n=90 (44.6%)	Day-shift workers n=112 (55.4%)	*P-value
Age (yrs)	Mean±SD		32.27±6.17	33.29±7.05	31.43±5.22	0.04[a]
Work experience (yrs)	Mean±SD		6.44±4.49	7.54±5.35	5.56±3.43	0.003[a]
Accident	Mean±SD		0.29±0.8	0.17±0.54	0.42±1.01	0.05 [a]
ESS total score	Mean±SD		9.33±4.02	9.4±3.66	9.27±4.3	0.817[b]
	Healthy	n (%)	94 (46.5)			
	Apnea	n (%)	108 (53.5)	51 (56.7%)	57 (50.9%)	0.414[c]
MEQ total score	Mean±SD		45.15±4.94	44.94±5.08	45.31±4.84	0.6[a]
	Intermediate	n (%)	155 (76.7)	68 (75.6%)	87 (77.7%)	0.723[c]
	Moderate evening	n (%)	47 (23.3)	22 (24.4%)	25 (22.3%)	
CIS total score	Mean±SD		62.85±12.93	61.12±10.66	64.23±14.4	0.08[a]
	CIS > 76	n (%)	29 (14.36)	7 (7.77%)	22 (19.64%)	0.017[c]

ESS=Epworth Sleepiness Scale, MEQ=Morningness-eveningness Questionnaire, CIS=Checklist Individual Strength,
* a=t-test, b=Mann-Whitney test, c=Chi-Square test, SD=standard deviation

rest of the subjects that consisted of the majority of the participants (n=155) were reported as the intermediate type and day-shift workers had a higher percentage.

The score of CIS (fatigue) was obtained as 64.23±14.4 and 61.12±10.66 in workers of day and rotating shifts, respectively. Among all workers, 29 people had a score of higher than 76, seven (7.77%) of which were rotating-shift workers and 22 (19.64%) worked day shifts. The relationship between the score of this questionnaire and the shift of the workers was significant (P=0.017). Further information could be observed in Table 2.

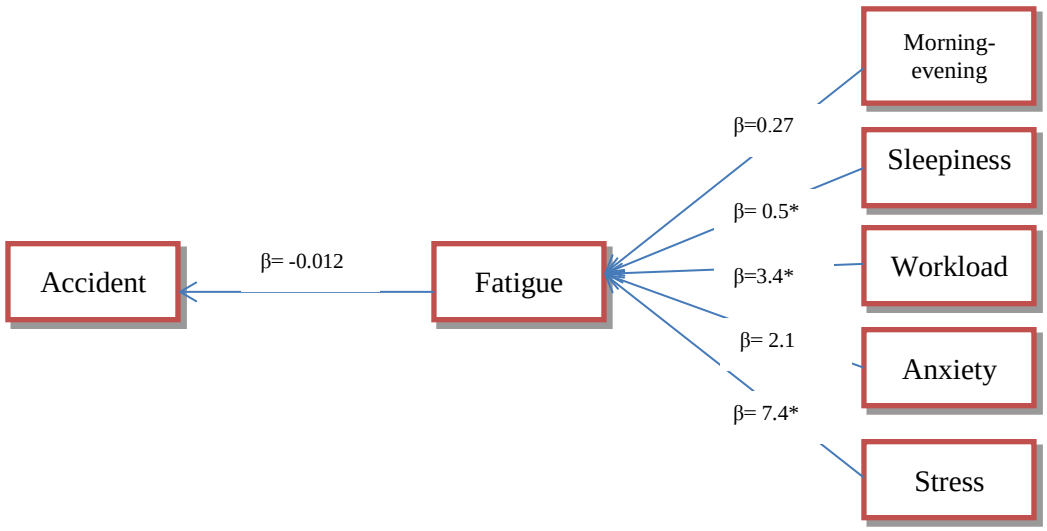

Figure 1) Structural equation of the relationship between variables among all workers (*P<0.05)

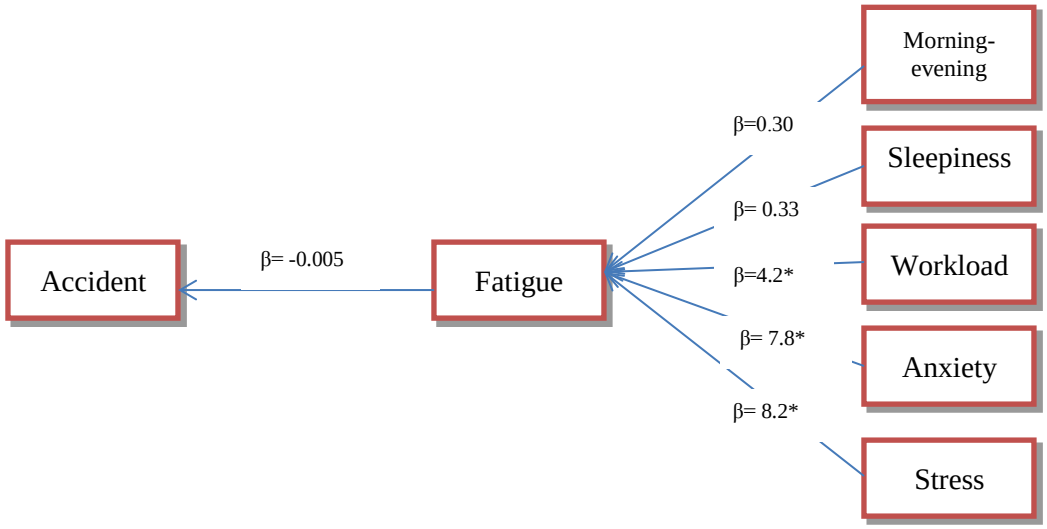

Figure 2) Structural equation of the relationship between variables day-shift workers (*P<0.05)

Following comparisons, the relationship between the variables was assessed using path analysis and structural equation. The analysis was first performed for all the personnel being studied. Afterwards, the day- and rotating-shift workers were analyzed separately, the output of which is shown in figures 1-3.

Discussion

The present study aimed to investigate the relationship between fatigue, sleepiness, workload, anxiety, stress, morning-evening type, and accidents. The results of this study did not report a direct relationship without a mediator between the mentioned factors and accidents. However, we observed that fatigue had a significant relationship with sleepiness, workload, anxiety, and stress. Therefore, a structural equation that indirectly leads to the accident through fatigue was assessed.

Despite the findings of the current study, numerous studies demonstrated that accidents

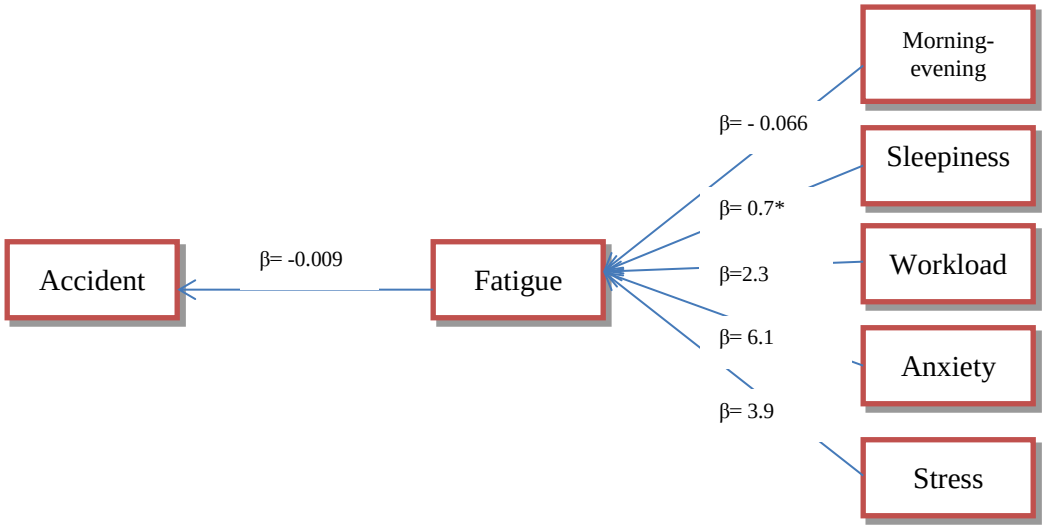

Figure 3) Structural equation of the relationship between variables among rotating-shift workers (*P<0.05)

have a significant direct relationship with sleep disorders (9-11, 32-35), fatigue (11-13, 36-38), stress (7, 13), anxiety (16, 17), workload (5, 6), as well as an indirect relationship with morning-evening (19-27).

Furthermore, some investigations have noted the role of rotating-shift work in this regard. For example, Garbarino et al. (2002) stated that the occurrence of sleep-related accidents is significantly higher in the rotating-shift group, in comparison with the non-rotating group (39).

Working as rotating shifts is highly prevalent among industrial societies (> 20%). However, working as night shifts imposes definite impacts on sleep, physical non-objective sleepiness, risk of accidents, and health consequences, such as cardiovascular diseases and some specific cancers (40).

In this regard, the current study evaluated the relationship between the aforementioned factors, in addition to investigating them separately in the two groups of rotating-shift work and non-rotating. As could be observed in figures 1-3, fatigue was shown to be correlated with sleepiness, workload, and stress among all the workers (P<0.05).

Moreover, fatigue had a relationship with workload, anxiety, and stress among the workers of day shifts (P<0.05). On the other hand, among the rotating-shift workers, fatigue was found to be correlated only with sleepiness (P<0.05). It should be noted that the relationship between fatigue as the mediating factor and accidents was not significant in this study (P>0.05).

Bolghanabadi et al. (2014) concluded that the number of accidents elevated in both night- and day-shift workers by an increase in the intensity of fatigue. Furthermore, they found a significant relationship between accidents and fatigue in the workers of night shifts, which is not in line with our study (P<0.001) (14).

However, some studies are consistent with the current investigation, such as the study completed by Grech et al. (2009). The latter authors clarified the relationship between workload and fatigue. They revealed that individuals should be recruited for tasks with moderate severity because both high and low workloads can result in fatigue (41).

Among the studies in Iran, Hassanzadeh et al. (2017) found a significant relationship between physical fatigue and workload in the target population of drivers (P<0.001) (42). Moreover, a significant correlation between occupational stress and fatigue have been investigated and

confirmed in Iranian studies (14).

People often get affected by physical problems or mental and psychological disorders, including fatigue, depression, and anxiety in the case of confronting stressful situations, such as divorce, job loss, and the death of family members or friends. As a result, they become psychologically or physically tired, feel unmotivated and tired for daily activities, and get affected by early fatigue in performing their activities.

Sleep deprivation and disorders could be important reasons for chronic fatigue in individuals. For example, sleep apnea leads to waking up and sleep disorder by generating irregular sleeping conditions and instant apnea in the person during the night. Consequently, the feeling of fatigue and low energy happens during daily activities.

It seems that the workers of rotating shifts are more prone to occupational accidents due to diverse reasons, including fatigue and the lack of concentration. This highlights the necessity of more attention to the balancing of shifts and workload among the workers of rotating shifts (37).

Conclusion

According to the findings of the present study, sleepiness, high workload, and stress are prevalent among the workers of the porcelain industry that significant results in fatigue. Subsequently, it is recommended to take into consideration the related factors and adopt control practices in this regard.

Furthermore, sleepiness was observed to be significantly correlated with fatigue in the workers of rotating shifts. Therefore, special attention should be paid to the important and basic factor of working on rotating shifts. This factor in combination with other variables, such as insufficient rest and older age can lead to fatigue, sleepiness, reduced agility, and accident occurrence.

With this background, control practices need to be applied, namely utilizing psychological approaches, taking into consideration the resting hours of individuals, providing effective pieces of training toward the enhancement of safety level, preventing the occurrence of occupational accidents, and reducing the working hours of individuals.

Footnotes

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Conflict of Interest

The authors of the present study declare no conflict of interest for this research.

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