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Work stress and hair cortisol levels among workers in a Bangladeshi ready-made garment factory — Results from a cross-sectional study

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Summary Evidence on the association of work stress with cortisol levels is inconsistent and mostly stems from Western countries, with limited generalizability to other regions of the

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world. These inconsistencies may partly be due to methodological limitations associated with the measurement of cortisol secretion in saliva, serum or urine. The present study set out to explore associations of work stress with long-term integrated cortisol levels in hair among 175 workers of an export oriented ready-made garment (RMG) factory in Dhaka, Bangladesh.

Work-related demands (WD), interpersonal resources (IR) and work-related values (WV) were assessed using a psychometrically evaluated interview. WD consisted of four items on physical demands, time pressure, worries about mistakes and exposure to abusive language. IR comprised five items addressing support, recognition, adequate payment, workers' trust in the management, and the management's trust in workers, as perceived by the workers. WV captured job security, promotion prospects and job latitude by three items. Hair cortisol concentrations (HCC) were analyzed by liquid chromatography—mass spectrometry. Stepwise multivariable linear regression models (backward elimination of predictors) were used to estimate associations of HCC with the three work stress components. For significant work stress component(s), further multivariable linear regression analyses were conducted to explore whether, and if so, which individual item(s) contributed most.

The mean HCC equaled 3.27 (SD 2.58) pg/mg. HCC were found to be significantly associated with WV (beta = 0.209, p = 0.021). Additional analyses of the three WV items revealed that this association was largely driven the item on ''promotion prospects'' (beta = 0.230, p = 0.007) implying that the perception of *good* promotion prospects was associated with *higher* HCC.

The finding of elevated HCC with good promotion prospects may initially seem counter-intuitive, but is supported by research documenting that job promotion may result in poorer mental well-being. Moreover, being promoted in the Bangladeshi RMG industry may represent a stressful experience: job promotions are rare in this setting and are associated with the need to meet exceptional job-related demands. Further research from ethnic and culturally diverse occupational settings is needed to test this hypothesis, to shed light on the reproducibility of our findings and to improve our understanding of the psychobiological implications of psychosocial working conditions across cultures and contexts.

1. Introduction

Work stress is common in Western work forces (National Institute for Occupational Safety and Health, 1999; European Foundation for the Improvement of Living and Working Conditions, 2006) and is assumed to represent an emerging concern in developing countries (Houtman et al., 2007). While a uniform definition of work stress is lacking, research predominantly conducted in Western countries has suggested theoretical models which are assumed to capture key components of stressful working experiences. The two most dominant and best researched of these models are the job demand control (JDC) model (Karasek, 1979) and the effort-reward imbalance (ERI) model (Siegrist et al., 2004). The JDC model conceptualizes work stress as resulting from situations with simultaneous exposure to high job demands (e.g., intense work) and low job control (e.g., reduced control over work, skill and variety of tasks). The ERI model, by contrast, posits that work conditions are particularly distressing when efforts (e.g., the working under time pressure and under insecure contracting conditions) are insufficiently reciprocated by rewards (e.g., adequate salary, good promotion prospects, job security and recognition from colleagues and supervisors).

Work stress (e.g. defined according to the JDC model or the ERI model) has been identified as a risk factor for adverse health outcomes (Siegrist et al., 2009). Amongst others, cortisol may represent a mediator of these associations (Staufenbiel et al., 2012). However, according to a systematic review, the evidence on associations between work stress and diurnal cortisol levels is mixed (Hansen et al., 2009). This may partly be explained by the reliance of previous studies on cortisol assessments in saliva, serum or urine, which are affected by the temporal and situational variability of cortisol secretion and issues of non-compliance (Stalder and Kirschbaum, 2012). In contrast, cortisol assessments based on *hair* are considered to be less affected by these methodological limitations. Another advantage of hair cortisol concentrations (HCC) is that they reflect patterns of long-term cortisol secretion (Stalder and Kirschbaum, 2012), thereby capturing exposure to the stress hormone cortisol cumulatively over long time periods. Considerable data has supported the validity and reliability of this method (summarized in Stalder and Kirschbaum, 2012). Though evidence is still limited, studies have found HCC to be associated with various stress-related chronic conditions, such as psychiatric diseases (Staufenbiel et al., 2012) and myocardial infarction (Pereg et al., 2011).

At least two previous studies investigating HCC have addressed potential occupational determinants: Manenschijn et al. (2011b) have observed higher HCC in employees working in shifts as compared to those not working in shifts. Furthermore, Dettenborn et al. (2010) have reported higher HCC among unemployed individuals compared to those in employment. To date however, specific associations of HCC with work stress remain unexplored. Furthermore, given that cultural factors may affect the appraisal of occupational stress (Mazzola et al., 2011), it is a large limitation of the extant work stress literature that the vast majority of published studies stems from Western populations.

The present study therefore set out to examine associations between HCC and work stress among employees of a ready-made garment (RMG) factory in Bangladesh. As such, ours is to our knowledge the first study to extend the predominant focus of endocrine work stress research to non-Western populations. This particular occupational research setting was chosen because it is known to be highly stressful: the exceptionally poor working conditions of RMG workers have been a matter of substantial international attention and have been considered disastrous and as being characterized by low wages, exposure to violence, and a high work load (Bajaj, 2010; Ashraf and Strümpell, 2011; Ethirajan, 2012; Yardley, 2012). Furthermore the setting of our study is of broader societal relevance, both locally and for Western countries: Bangladesh is one of the leading exporters of ready-made garments worldwide (World Trade Organization, 2011) and produces almost exclusively for markets in Europe and North America (Ahmed and Ahmed, 2011). Furthermore, RMG workers represent one of the largest professional groups in Bangladesh (approximately 4 million workers). Research into the psychosocial work conditions and their potential health effects in this occupational population is therefore of public health interest.

Given that previous studies suggested associations of HCC with chronic stress (Van Uum et al., 2008) or occupational factors (Dettenborn et al., 2010; Manenschijn et al., 2011b) and given the notion that previous inconsistencies in findings regarding the association of cortisol and work stress might be attributed to methodological limitations of short-term cortisol assessments (Stalder and Kirschbaum, 2012), we set out to determine associations between work stress and HCC. We hypothesized that work stress in the RMG setting in Bangladesh would be associated with elevated HCC.

2. Methods

2.1. Setting and participants

Details on this study have been published elsewhere (Steinisch et al., 2013). Briefly, between February and March 2012, a cross-sectional interview-based study was conducted among workers of an export-oriented RMG factory in Dhaka, Bangladesh. A total of 553 workers were employed in the selected factory and valid interview data were obtained from 514 (93%) individuals. Of these, a total of 131 female and 44 male workers provided hair samples (34%). This study received ethical approval by the Bangladesh Medical Research Council and was conducted in accordance with the Declaration of Helsinki. All procedures were carried out with written informed consent of the participants.

2.2. Work stress measures

Work stress was measured by a psychometrically evaluated interview (Steinisch et al., 2013) combining a seven-item version of the ERI questionnaire (Siegrist et al., 2009) with five setting-specific items derived from previous ethnographic research (Ashraf and Strümpell, 2011). The seven-item ERI questionnaire captured ''efforts'' by two items (perceived physical demands and time pressure) and ''rewards'' by five items (perceptions of social support, salary, recognition, promotion prospects, and job security). The five setting-specific items addressed worries about making mistakes, exposure to abusive language, workers' trust in the management, and the management's trust in workers, as perceived by the workers, and job latitude. The latter set of items was added based on the hypothesis that the perception of work stress is considerably influenced by contextual factors such as the cultural environment (Chun et al., 2006) and that Western work stress scales might therefore not necessarily cover all dimensions of work stress that are relevant to the workers in the RMG setting in Bangladesh.

The twelve items included in the employed questionnaire clustered into three components: *work-related demands* (WD) (four items on high physical demands, time pressure, worries about mistakes, exposure to abusive language), *interpersonal resources* (IR) (five items on respectively support, recognition, adequate payment, workers' trust in the management, and the management's trust in workers, as perceived by the workers), and *work-related values* (WV) (three items on job security, promotion prospects, and job latitude). A sum score was calculated for each component. Higher scores indicate higher *work-related demands*, *interpersonal resources* and *work-related values*, respectively.

2.3. Hair cortisol analyses

Participants provided one or two hair strands with a diameter of 2–3 mm each. Hair strands were taken as close to the scalp as possible from a posterior vertex position. One scalp-near 2 cm hair segment was used for the analysis of HCC, which is assumed to reflect a 2-month period of hair growth. Wash and steroid extraction procedures followed the laboratory protocol described by Gao et al. (2013). Hair samples were washed with 2.5 mL isopropanol for 3 min and cortisol was extracted from 10 mg of whole, nonpulverized hair using 1800 μL methanol in the presence of cortisol-d_4 as internal standard for 18 h at room temperature. Following centrifugation at 15,200 × *g* for 2 min and transferring of 1 mL of the clear supernatant into a new 2 mL tube, the alcohol was evaporated at 65 °C under a constant stream of nitrogen and reconstituted with 250 μL double-distilled water. 200 μL was subsequently injected into a Shimadzu HPLC-tandem mass spectrometry system (Shimadzu, Canby, Oregon) coupled to an ABSciex API 5000 Turbo-ion-spray triple quadrupole tandem mass spectrometer (AB Sciex, Foster City, California) with purification by on-line solid-phase extraction. Lower limits of quantification of this assay have been shown to be below 0.1 pg/mg cortisol, with inter- and intra-assay coefficients of variance between 3.7% and 8.8% (Gao et al., 2013).

2.4. Statistical analyses

HCC data were ln-transformed to establish a normal distribution. Four outliers with standardized residuals exceeding 3.0 were excluded prior to statistical analyses, which resulted in an analytical sample of 171 participants. First, characteristics of participants from whom hair samples were collected were compared with those who had not provided hair (chi-squared tests and *t*-tests). Second, in exploratory analyses associations of HCC with demographics, occupational and health-related variables were examined (Pearson correlational analyses for continuous variables and ANCOVA for categorical variables). Third, stepwise multivariable linear regression analyses with backward elimination of predictors were run to examine associations of the individual work stress components or potential confounders with HCC ($n = 119$). The final model was chosen based on the criteria *F* probability to enter ≤ 0.05 and *F* probability to remove ≥ 0.10. For the significant work stress component(s), further multivariable linear regression analyses with backward elimination of predictors were conducted to explore whether, and if so, which individual item(s) contributed most.

All analyses, including the initial multivariable model for backward elimination analyses, were controlled for variables (1) which were identified as potential confounders in previous research (Dettenborn et al., 2012; Feller et al., 2014), and (2) which were assumed to show some variation within the study sample. While alcohol consumption, obesity and dying of hair, for instance, may represent determinants of HCC (Manenschijn et al., 2011a; Stalder et al., 2012; Manenschijn et al., 2013), these variables were unlikely to vary in our study sample: Bangladeshi population samples do usually not report alcohol consumption (World Health Organization, 2011). Further, during the conduct of a face-to-face pilot study in the selected RMG factory (Steinisch et al., 2013), we observed that none of the worker was obese and none seemed to dye their hair. Thus, these items were not assessed as they are unlikely to exert confounding effects. In the present study the following set of confounders was therefore used: age (20 or younger/21—29/30—39/40—49/50—59), sex (female/male), current tobacco use (yes/no) and poor self-reported health (SRH) (yes/no).

In our study setting, hierarchy and assigned tasks are strongly linked to gender (Ashraf and Strümpell, 2011). As this may contribute to differing perceptions of work stress, we ran sensitivity analyses restricted to non-supervising women as these represent the largest subgroup in our study. SPSS 21 was used for all analyses.

3. Results

Among the survey participants (84% women), men were relatively more likely to provide hair than women ($p < 0.0001$), unmarried participants were more likely to provide hair than married participants ($p = 0.006$), and tobacco users were more likely to provide hair than non-users ($p = 0.007$). Also, poor self-rated health was positively associated with the provision of hair ($p = 0.006$). The sample included in the present analysis (i.e. those providing both interview data and hair) mainly consisted of young female employees with low educational backgrounds who were employed as workers (as opposed to supervisors/managers, see Table 1). Daily income was equal to or less than 230 Bangladeshi Taka (BDT) ($2.8) for 85% of the employees. Mean weekly overtime equaled 7.3 h (SD 4.3). Fifty per cent of the workers reported poor health. Mean scores of the work stress component scales were 6.3 (SD 1.3) for *WD* (potential range: 4—8), 9.4 (SD 0.9) for *IR* (potential range: 5—10) and 4.6 (SD 1.0) for *WV* (potential range: 3—6). The mean HCC was 3.27 (SD 2.58) pg/mg. As shown in Table 1, HCC did not significantly differ across the respective subgroups for age, sex, marital status, education, type of job within the factory, daily income, weekly over hours, tobacco use or SRH.

Using stepwise backward multivariable regression analyses, the final model after removal of variables according to the probability of *F*-to-remove included age and *work-related values* (WV). The variable WV showed a significant association with HCC (beta = 0.209, $p = 0.021$) (see Table 2). Increasing WV scores were associated with increasing HCC, implying that a sum score reflecting better promotion prospects, higher job latitude and higher job security was related to *higher* HCC. When we examined each of these items' contribution to the overall association of WV with HCC, only the item on promotion prospects showed a significant association with HCC (beta = 0.230, $p = 0.007$) (see Table 3). Mean cortisol values were 3.50 (SD 2.63) pg/mg for those reporting high promotion prospects versus 2.67 (SD 1.83) pg/mg among those with low promotion prospects.

Rerunning the backward multiple regression analyses restricted to non-supervising women yielded the same pattern of associations as observed in the primary analyses: age and work-related values showed significant associations with HCC (beta = −0.230, $p = 0.032$ and beta = 0.243, $p = 0.024$, respectively). Again, only the item reflecting promotion prospects showed a significant relationship with HCC (beta = 0.281, $p = 0.006$) when we assessed associations of each WV item with HCC (data not shown in tables).

4. Discussion

To the best of our knowledge, this is the first study to study associations between work stress and HCC. Our findings add to evidence from studies highlighting other types of occupational determinants of HCC levels, i.e., unemployment and shift work (Dettenborn et al., 2010; Manenschijn et al., 2011b). Moreover, our study is one of few investigating HCC and endocrine responses to stress exposure in a non-Western setting. Our findings add to the recent reports regarding potential associations between the exposure to work stress and diurnal cortisol levels: Three reviews have been published on adverse psychosocial working conditions and cortisol levels (Chida and Steptoe, 2009; Hansen et al., 2009; Chandola et al., 2010). Two of these, involving 16 and 28 studies, respectively, were unable to find consistent associations of work stressors and diurnal cortisol levels in serum or urine (Hansen et al., 2009; Chandola et al., 2010). While these inconsistencies may partly be due to difficulties with the measurement of long-term cortisol secretion in saliva, serum or urine, the current study presents a promising novel approach which is considered a more appropriate indicator of long-term integrated cortisol levels.

Out of three work stress components, only *WV* showed a significant association with HCC in our study population. Notably, favorable *work-related values* were associated with *higher* HCC. This relationship is not in keeping with the assumption that work stress exposure (i.e. *adverse work*

Table 1 Characteristics of the study sample and exploratory analyses with hair cortisol concentrations (HCC).

Characteristics		Association with HCC[i]		
		F (df_M, df_R)[a]	r (df)[b]	p-Value
Cortisol (pg/mg) (n = 171), mean (SD[c])	3.27 (2.58)			
Age, n (%)		1.41 (3, 163)		0.243
≤20 years	94 (55.3)			
21–29 years	55 (32.4)			
30–39 years	14 (8.2)			
40–49 years	7 (4.1)			
Female, n (%)	129 (75.4)	0.25 (1, 165)		0.616
Marital status, n (%)		0.36 (1, 164)		0.246
Married	74 (43.3)			
Unmarried	97 (56.7)			
Education, n (%)		0.06 (2, 163)		0.943
No formal education	17 (9.9)			
Grade 1–10	140 (81.9)			
Lower secondary exam or higher	14 (8.2)			
Type of Job within factory, n (%)		0.21 (1, 164)		0.651
Workers	156 (91.2)			
Supervisor or manager	15 (8.8)			
Daily income, mean BDT[d] (SD) (n = 152)	192.25 (122.96)		0.03 (146)	0.706
<37 BDT[e]	1 (0.7)			
37.1–115 BDT[f]	11 (7.2)			
115.1–230 BDT[g]	118 (77.6)			
>230 BDT	22 (14.5)			
Weekly overtime hours (n = 136), mean, SD	7.3 (4.3)		0.04 (130)	0.662
Tobacco use, n (%)		0.01 (1, 165)		0.939
Yes	25 (14.6)			
No	146 (85.4)			
Poor self-rated health, n (%)[h]	86 (50.3)	0.10 (1, 165)		0.747

[a] Ancova F-ratio (degrees of freedom for the effect of the model (df_M), degrees of freedom for the residuals of the model (df_R) for categorical variables).
[b] Pearson's r-Coefficient (degrees of freedom (df)) for continuous variables.
[c] Standard deviation.
[d] BDT, Bangladeshi Taka.
[e] 37 BDT equal the extreme international poverty line of 1.25 USD purchasing power parity.
[f] 115 BDT/day equate to the national minimum wage of 3000 BDT/month at 26 working days (Bangladesh Ministry of Labour and Employment. People's Republic of Bangladesh, 2010). 3000 BDT/month equal 35.7 USD/month.
[g] 230 BDT equal 2.8 USD.
[h] Self-rated health (SRH) was measured using a 5-point Likert scale ranging from very good to very bad. Moderate, bad and very bad SRH were categorized into poor SRH.
[i] Adjusted for age, sex, tobacco use and self-rated health.

related-values) is associated with higher HCC. Out of the three separate *WV* items only the item addressing *promotion prospects* was associated with HCC. This observation might highlight an association specific to the occupational context of our study: Promotions in the RMG industry of Bangladesh involve pressure to perform exceptionally well at work and require extraordinary loyalty to the management as well as readiness to penalize coworkers. Those perceiving their promotion prospects as good or who are actually being considered for promotion may thus be more likely to experience their work as stressful (H. Ashraf, personal communication).[1] Our findings may however have generalizability beyond our study setting. Recent studies conducted in Western countries and across various occupational groups have highlighted that actual job promotion may be detrimental to mental wellbeing (Boyce and Oswald,

[1] HA conducted anthropological fieldwork in a Bangladeshi RMG factory for a period of 14 months.

Table 2 Associations of HCC with work stress components.

Model (n)	Indicator	Indicator parameters: Beta	Indicator parameters: *p*-Value	Model parameters: Adjusted *R*-Square	*F*-ratio (dF_M, dF_R[b])	*p*-Value of the model	ΔAIC[c]
6 (119)	Work related values[a]	0.209	0.021	0.057	4.545 (2, 116)	0.013	0.377
	Age	−0.174	0.053				

[a] Job security, promotion prospects, job latitude.
[b] Ancova F-ratio (degrees of freedom for the effect of the model (dfM), degrees of freedom for the residuals of the model (dfR) for categorical variables).
[c] Akaike information criterion.

2012; Johnston and Lee, 2012). One may hypothesize that job promotion exerts its adverse health effects already upon its anticipation (in contrast to actual promotion).

An alternative explanation for this particular finding may be put forward: Assuming that the lack of promotion prospects is in fact perceived as a stressor, our findings might be explained by the hypothesis that prolonged stress has the potential to *diminish* HPA axis activity. Long term levels of cortisol as detected in hair have been found to be blunted in patients with posttraumatic stress disorder (Luo et al., 2012; Steudte et al., 2013) and in patients with generalized anxiety disorder (Steudte et al., 2011). Due to the psychopathological character of the stressors in those studies, their findings might not necessarily be transferable to the work place setting of our study. However, one has to consider the possibility that under certain circumstances of chronic stress exposure HPA axis activity is potentially diminished — thereby allowing the alternative hypothesis that in workers with poor promotion prospects cortisol secretion may be blunted. Further research is needed to determine whether chronic and ongoing psychosocial stress exposure, as experienced in the current setting, has the potential to diminish HPA axis activity.

The lack of consistency of associations between self-reported work stress measures and HCC, as observed in our study, is in keeping with various previous studies on self-reported stress measures and HCC (Stalder and Kirschbaum, 2012; Staufenbiel et al., 2012). It has been argued that this inconsistency of findings may stem from the fact that self-reported stress measures and HCC may refer to different time periods (Staufenbiel et al., 2012): HCC is assessed for a fixed time period defined by the length of the hair strand, while interviews used to assess work stress often fail to provide any reference time frame to respondents' recall and might not or only partially reflect the time period covered by HCC. This could represent an alternative explanation for the findings of the current study. Information on the duration of participants' employment in the garment sector would have been useful to improve our understanding of the potential correspondence of the time frame reflected by HCC and potential exposure to work stress related to working in the RMG industry. However, as suggested by a pilot study it was not feasible to obtain this information based on self-reports in the current setting: RMG staff in Bangladesh usually works intermittently and switches between factories and thus the exact number of months of employment during a previous period of several years seemed to be too complex to recall accurately.

Another limitation of our study is its cross-sectional design, as it does not allow exploring the temporal sequence between work stress and HCC. The present analyses controlled for several confounders which were suggested by prior research (Dettenborn et al., 2012; Feller et al., 2014) and which were assumed to show reasonable variation when assessed in the study sample. We were unable, however, to adjust for specific diseases such as cardiovascular disease and diabetes mellitus which are potentially associated with both work stress (Kivimäki et al., 2012; Li et al., 2013) and cortisol levels (Manenschijn et al., 2013; Stalder et al., 2013; Feller et al., 2014). In addition, glucocorticoid medication may affect HCC levels. One may assume, however, that these adverse health outcomes were captured to some extent by our adjustment for poor self-rated health, which is an accepted indicator of overall morbidity (Idler and

Table 3 Associations of HCC with individual items of the work stress component work-related values.

Model (n)	Indicator	Indicator parameters: Beta	Indicator parameters: *p*-Value	Model parameters: Adjusted *R*-Square	*F*-ratio (dF_M, dF_R[a])	*p*-Value of the model	ΔAIC[b]
6 (135)	Promotion prospects	0.230	0.007	0.055	4.888 (2, 132)	0.009	0
	Age	−0.147	0.083				

[a] Ancova F-ratio (degrees of freedom for the effect of the model (dfM), degrees of freedom for the residuals of the model (dfR) for categorical variables).
[b] Akaike information criterion.

Benyamini, 1997). Furthermore, the study participants were young, and prevalences of cardiovascular disease or diabetes mellitus would thus likely be low and may therefore only have limited effects on our estimates. Possibly, our study had limited statistical power because HCC showed very little variance (SD 2.58 pg/mg) and a restricted range (0.53—18.60 pg/mg) in comparison to HCC assessments reported elsewhere: Dettenborn et al. (2012), for instance, report a mean cortisol level of 16.28 (SD 10.3) pg/mg among 360 study participants in Germany. Further, the restricted variance might be explained by the fact that the group of hair-providing study participants might represent a distinct subpopulation, differing from the total sample of workers in the factory. Only 34% of the interviewed participants provided hair samples. This low response rate may be associated with selection bias (e.g., healthy worker effect). However, a healthy worker effect is not supported by our data; in fact, those providing hair samples specified significantly *poorer* health than the study participants who did not provide hair samples. Notably, the demographic characteristics of those included in these analyses largely correspond with the common demographic profile of RMG work forces (Paul-Majumder, 2003). It is important to note, though, that the generalizability of our findings to other industrial settings or other employment sectors in Bangladesh still needs to be determined. Finally, our study would have benefited from a control group (e.g. a representative sample of the Bangladeshi workforce), which would have improved our ability to interpret detected HCC differences by promotional prospects. Unfortunately, inclusion of such a control group was not feasible.

In conclusion, in the present study we observed a significant association of increased HCC with good promotion prospects. Explanations of this finding may include factors that are specific to the occupational environment in the RMG setting (i.e. promotion prospects being associated with particularly high work stress). Alternatively, the findings add to recent research in other occupational settings and countries which has highlighted the adverse effects of being promoted to mental wellbeing. Thus, the perception of promotion prospects (or actual promotion) as being stressful might generalize beyond the RMG setting rather than representing a contextual peculiarity. Further research from ethnic and culturally diverse occupational settings is needed to test this hypothesis, to shed light on the reproducibility of our findings and to improve our understanding of the psychobiological implications of employment circumstances across cultures and contexts.

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Conflict of interest

None declared.

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