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Original Article

Temporomandibular disorder severity and diagnostic groups: Their associations with sleep quality and impairments

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ABSTRACT

Objectives: This study evaluated the impact of TMD severity on sleep quality and established the associations between TMD diagnostic groups/pain subtypes and sleep impairments.
Methods: A total of 1151 patients from a tertiary Dental Hospital were screened for eligibility. Consenting subjects who met the inclusion criteria were directed to complete a general/health questionnaire, the Fonseca Anamnestic Index (FAI), Diagnostic Criteria for Temporomandibular disorders (DC/TMD) Symptom Questionnaire, and Pittsburgh Sleep Quality Index (PSQI) at their intake visit. Patients who screened positive for TMDs with the FAI were subjected to a protocolized physical examination and TMD diagnostic groups/subtypes were subsequently derived based on the DC/TMD "diagnostic tree" and algorithms. Statistical analyses were conducted using non-parametric methods and logistic regression ($\alpha = 0.05$).
Results: The final sample consisted of 845 subjects with TMDs and 116 TMD-free controls. The mean age of the TMD and TMD-free subjects were 33.17 ± 13.55 and 31.66 ± 9.50 years. Subjects with severe and moderate TMDs had significantly greater global PSQI scores than those with mild and no TMDs ($p < 0.001$). Those with pain-related, intra-articular, and combined TMDs reported significantly poorer sleep quality than those with no TMDs ($p < 0.001$). Moreover, subjects with myalgia and myalgia plus arthralgia presented significantly greater sleep impairments than their counterparts with intra-articular disorders ($p < 0.001$). Multivariate logistic regression indicated that pain-related (OR = 3.23; CI = 1.69–6.14) and intra-articular TMDs (OR = 1.91; CI = 1.15–3.16) were most related to poor sleep.
Conclusions: Sleep quality worsened with increasing TMD severity and the presence of painful and intra-articular TMDs increased the likelihood of poor sleep.

1. Introduction

Sleep is a "behaviourally regulated drive" involving a state of reduced responsiveness to external stimulus [1]. It is important for maintaining homeostasis and optimizing multiple physiological functions including memory consolidation, mood maintenance, hormone regulation, immune system recovery, brain and muscle regeneration as well as energy balance [1–3]. Sleep is regulated by the suprachiasmatic nucleus as well as the thalamus and involves a

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circadian rhythm that is influenced by environmental and light cues [2]. It can be divided into 3–5 cycles of non-rapid eye movement (REM) and REM periods with REM latencies varying from 90 to 120 min. Non-REM sleep can be further classified into light (stages N1 and N2) and deep (stages N3 and N4) sleep [4]. In addition to the various physiological functions, sleep has also been linked to pain including chronic orofacial pain. A bidirectional relationship between sleep quality and pain has been posited with both circular and linear models [1,5,6]. Longitudinal studies indicate that sleep quality consistently predicted pain incidence and exacerbations. Moreover, sleep impairments were found to be a greater and more reliable predictor of pain than pain is of sleep problems [1].

Temporomandibular Disorders (TMDs) are a cluster of medical and dental conditions characterized by pain and dysfunction of the Temporomandibular joints (TMJs) as well as masticatory muscles. They are a frequent source of chronic orofacial pain and affect up to 15% of adults with women demonstrating a two times greater risk [7,8]. The features of TMDs include craniofacial and periauricular pain, TMJ noises as well as jaw movement difficulties and restrictions. The multifactorial etiology of TMDs is highly complex and consistent with a "biopsychosocial model of illness" with up to 60.1% of TMD patients presenting moderate-to-severe depression [9,10]. The contemporary benchmark for TMD assessment and diagnoses is the Diagnostic Criteria for TMDs (DC/TMD) [11]. With reference to the DC/TMD, common TMD conditions can be categorized into pain-related (primarily myalgia and arthralgia) and intra-articular (primarily disc displacements and degenerative joint disease) disorders.

Systematic reviews have demonstrated that TMDs lower quality of life and therapeutic TMD interventions improve it [12,13]. Similarly, studies have also shown an association between TMDs and sleep with the presence of pain strongly impairing sleep quality in TMD patients [6]. These studies were based mostly on the Pittsburgh Sleep Quality Index (PSQI) which has strong reliability and validity [14]. More recently, Kim et al. determined that 78.4% of patients with painful TMDs suffered from poor quality sleep using the PSQI [15]. To further complicate matters, sleep-related movement and breathing disorders, namely sleep bruxism (SB) and obstructive sleep apnea (OSA) had also been implicated as TMD risk factors [16–19]. SB (ie the clenching and/or grinding of teeth during sleep) has been related to myalgia, arthralgia, and intra-articular disorders and attributed to biomechanical overloading as well as micro-trauma [16,17]. Considering the plausible relationship between SB and OSA, patients with TMDs may present with OSA and contrariwise [18]. Both cohort and case–control studies have specified a significant relationship between TMDs and OSA, with prospective evidence indicating that symptoms of OSA preceded first-onset TMDs [19].

Although the association between TMDs and sleep had been explored, research on sleep impairments in relation to TMD severity and differentiated DC/TMD diagnostic groups/subtypes is still scarce. Moreover, most prior works had involved relatively small TMD cohorts and Western populations. Studies on Chinese samples are essential given the greater vulnerability of Chinese to OSA due to craniofacial bony restrictions [20]. Therefore, the objectives of this study were to examine the impact of TMD severity on sleep quality and to establish the associations between TMD diagnostic groups/pain subtypes and sleep impairments. The secondary objective was to establish socio-demographic and TMD-related factors for poor sleep. The null hypotheses were as follows: (a) sleep quality is not influenced by TMD severity, (b) no difference in sleep variables exists among the various DC/TMD diagnostic groups as well as pain subtypes, and (c) no socio-demographic and TMD-related factors predispose subjects to poor sleep.

2. Methods

2.1. Participants

Approval was obtained from the Biomedical Institution Review Committee of Peking University School of Stomatology (reference no. PKUSSIRB-201732009) before starting the study. A minimum sample size of n = 416 was confirmed a priori using the G*Power Software version 3.1.9.3 [21], based on the Wilcoxon-Mann-Whitney model with an effect size of 0.50, alpha error 0.05, power of 95%, allocation ratio of 7, and previous work [22]. The study participants were recruited from consecutive patients attending the TMD/Orofacial Pain and Prosthodontic units of a tertiary Dental Hospital over 24 months. The inclusion criteria were patients ≥18 years of age and the presence (TMD group) or absence of TMD (TMD-free group) symptoms. Patients with prior facial/cervical trauma, drug abuse, major psychiatric disorders, uncontrolled autoimmune or metabolic diseases, cognitive impairments, and illiteracy were excluded. Involvement in the study was completely voluntary and written informed consent was obtained from all participants. At their intake visit, the subjects were directed to complete a general and health questionnaire, the Chinese versions of the Fonseca Anamnestic Index (FAI) [23], the DC/TMD Symptom Questionnaire (SQ) [24], and the Pittsburgh Sleep Quality Index (PSQI) [25].

2.2. measures

The FAI was used to screen for the presence of TMDs and to classify TMD severity. It consists of 10-items encompassing pain-related (headache, TMJ, masticatory muscle, and neck pain) and function-related (TMJ sounds, jaw opening, and side-movement difficulties) TMD symptoms as well as TMD risk factors (teeth clenching, malocclusion, and emotional stress). A 3-point response scale is used to score the questions with no = 0 points, sometimes = 5 points, and yes = 10 points. TMD severity was categorized as follows: No TMDs = 0 to 15 points; mild TMDs = 20 to 40 points; moderate TMDs = 45 to 65 points; and severe TMDs = 65 to 100 points. The DC/TMD SQ consists of 14-items concerning the characteristics and history of facial pain, headaches, TMJ noises, closed, and open locking. It enables the standardized collection of essential information for forming the DC/TMD Axis I (physical) diagnoses.

Sleep quality was examined with the PSQI that entails 19-items and seven components (ie subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction).

The majority of items are scored on a 4-point response scale with 0 = not during the past month to 3 = three or more times a week or 0 = very good to 3 = very bad. Individual component scores are computed based on specified rules and the global PSQI score is attained by totaling the seven component scores. Global PSQI scores range from 0 to 21 points with greater scores indicating worse sleep quality. A global PSQI score >6 was utilized as the cut-point for poor sleep [25].

2.3. DC/TMD diagnoses and pain subtypes

Patients who screened positive for TMDs with the FAI were subjected to a standardized physical examination according to the DC/TMD protocol [24]. This was performed by a single TMD specialist who was officially trained and calibrated in the DC/TMD clinical examination according to the DC/TMD training and calibration guidelines [26]. Outcomes of the SQ and physical examinations were used to derive the DC/TMD Axis I diagnostic groups

and pain subtypes based on the DC/TMD "diagnostic tree" and algorithms. The DC/TMD diagnostic groups were subsequently organized into three groups, namely pain-related TMDs (PT), intra-articular TMDs (IT), and combined TMDs (CT). Painful TMD subtypes were further stratified into myalgia (ie muscle pain [MP]), arthralgia (ie joint pain [JP]), myalgia plus arthralgia (ie combined pain [CP]), and related to the IT (or non-painful TMDs [NP]) and CT groups.

2.4. Statistical analyses

The IBM SPSS Statistics for Windows software Version 24.0 (IBM Corporation, Armonk, New York, USA) was employed for statistical analyses with the significance level set at 0.05. Data distribution was examined with the Shapiro–Wilks test. Categorical data were displayed as frequencies with proportions while numerical ones were presented as means (with standard deviations) as well as medians (with interquartile ranges). The Chi-square test was used to compare gender distributions for the various TMD groups. Non-parametric analyses (Kruskal–Wallis and Mann–Whitney U post-hoc test) were conducted to evaluate age, PSQI global, and component scores among TMD groups as data were not normally distributed. Univariate and multivariable logistic regressions were carried out to determine quantitative associations for poor sleep (global PSQI $\geq$6) and presented as odds ratios (ORs) with 95% confidence interval (95% CI). For the multivariate model, a stepwise variable selection method with a cut-off point of $p < 0.10$ for eliminating insignificant variables was applied.

3. Results

3.1. Demographic data

A total of 1151 patients were screened for eligibility of which 190 declined participation or met the exclusion criteria. The final sample (n = 961) consisted of 845 subjects with TMDs and 116 TMD-free controls (Table 1). The mean age of the TMD and TMD-free subjects were 33.17 ± 13.55 and 31.66 ± 9.50 with women forming 81.42% (688/845) and 62.93% (n = 73/116) correspondingly. Significant age differences were observed between subjects with moderate and severe TMDs ($p = 0.031$) and those with PT, IT, and CT ($p < 0.001$). Subjects with severe and pain-related TMDs were generally older. The proportion of women were significantly greater than men for all TMD severity and diagnostic groups ($p < 0.001$). The mean and median global and component PSQI scores for the various TMD severity, diagnostic, and subtype groupings are presented in Tables 2–4 accordingly. Table 5 shows the results of univariate and multivariate logistic regression analyses of predictors for poor sleep.

3.2. TMD severity and sleep quality

Based on the FAI, 12.07% of the subjects had no TMDs while 24.56%, 40.37%, and 23.00% experienced mild, moderate, and severe TMDs respectively. Mean global PSQI scores ranged from 5.00 ± 2.22 to 8.40 ± 4.02 for the no and severe TMDs groups. Subjects with severe and moderate TMDs had significantly greater global PSQI scores than those with mild and no TMDs. Global PSQI scores between the severe and moderate groups also differed significantly. For the seven sleep components, significant differences in scores were as follows: Subject sleep quality – severe > moderate > mild > no TMDs; Sleep latency – severe > moderate > mild, no TMDs; Sleep duration – severe > moderate, mild, no TMDs; Sleep efficiency – severe > moderate, mild > no TMDs; Sleep disturbance – severe > moderate > mild > no TMDs; Use of sleep medication – severe > moderate, mild, no TMDs; Daytime dysfunction – severe > moderate > mild, no TMDs.

3.3. TMD diagnostic groups/pain subtypes and sleep quality

Among the subjects with TMDs, 12.19%, 47.46%, and 40.35% had PT, IT, and CT following the DC/TMD. Mean global PSQI scores varied from 6.22 ± 3.20 to 8.16 ± 4.54 for the IT and PT groups accordingly. Subjects with any DC/TMD diagnoses (ie PT, IT, or CT) presented significantly higher global PSQI scores compared to those with no TMDs (NT). In addition, the PT group had significantly greater global PSQI scores than the IT group. Significant differences in sleep component scores among the TMD diagnostic groups were: Subject sleep quality – NT > PT, IT, CT; Sleep latency – PT, CT, IT > NT; Sleep duration – PT > IT, NT and CT > IT; Sleep efficiency – PT > CT, IT > NT; Sleep disturbance – PT, CT > IT > NT; Use of sleep medication – PT > IT, NT and CT > NT; Daytime dysfunction – PT, CT, IT > NT.

With regards to painful TMD subtypes, mean global PSQI scores ranged from 6.86 ± 3.73 to 12.33 ± 6.25 for the CT and MP groups. The CP and MP groups had significantly higher global PSQI scores than the NP group with only intra-articular disorders. No significant differences in global PSQI scores were observed between the MP, JP, CP, and CT groups. The significant differences in sleep component scores between the TMD subtypes were as follows: Subject sleep quality – CP > CT, NP; Sleep latency – NS; Sleep duration – MP > NP; Sleep efficiency – MP > NP; Sleep disturbance – MP, CT > NP; Use of sleep medication – CP > NP; Daytime dysfunction – NS (where NS indicates no statistically significant differences).

3.4. Predictors of poor sleep

Multivariate logistic regression indicated that the following factors increased the likelihood for poor sleep: pain-related TMDs (OR = 3.23; CI = 1.69–6.14), intra-articular TMDs (OR = 1.91; CI = 1.15–3.16), combined TMDs (OR = 1.17; CI = 0.84–1.63), and

Table 1
Characteristics of the study population.

Measure	TMD severity or subtypes	Age Mean ± SD	Age Median (IQR)	p-value	Total n (%)	Male n (%)	Female n (%)	p-value
FAI (n = 961)	No TMDs	31.66 ± 9.50	29.00 (8.75)[a,b]	0.031*	116 (12.07)	43 (37.07)	73 (62.93)	<0.001#
	Mild TMDs	33.26 ± 14.27	28.50 (17.75)[a,b]		236 (24.56)	68 (28.81)	168 (71.19)	
	Moderate TMDs	32.27 ± 13.24	28.00 (14.00)[b]		388 (40.37)	65 (16.75)	323 (83.25)	
	Severe TMDs	34.65 ± 13.24	30.00 (19.00)[a]		221 (23.00)	24 (10.86)	197 (89.14)	
DC/TMD (n = 845)	Pain-related TMDs	42.35 ± 15.94	40.00 (24.00)[a]	<0.001*	103 (12.19)	30 (29.13)	73 (70.87)	<0.001#
	Intra-articular TMDs	29.20 ± 10.52	26.00 (11.00)[b]		401 (47.46)	84 (20.95)	317 (79.05)	
	Combined TMDs	35.06 ± 14.20	30.00 (21.00)[c]		341 (40.35)	43 (12.60)	298 (87.40)	

Results of Kruskal–Wallis/Mann–Whitney U post-hoc with Bonferroni correction* and chi-square test# ($p < 0.05$). Same letters indicate no statistically significant difference, while different letters indicate statistically significant differences.

Table 2
Mean (±standard deviations) and median (inter-quartile range) PSQI scores for the four TMD severity groups.

Variables		No TMDs	Mild TMDs	Moderate TMDs	Severe TMDs	p-value
Global PSQI	Mean ± SD	5.00 ± 2.22	5.38 ± 2.97	6.57 ± 3.44	8.40 ± 4.02	<0.001*
	Median (IQR)	5.00 (2.75)[a]	5.00 (4.00)[a]	6.00 (4.00)[b]	8.00 (5.00)[c]	
Subjective sleep quality	Mean ± SD	1.70 ± 1.01	1.00 ± 0.65	1.18 ± 0.73	1.40 ± 0.77	<0.001*
	Median (IQR)	2.00 (1.00)[a]	1.00 (0.00)[b]	1.00 (1.00)[c]	1.00 (1.00)[d]	
Sleep latency	Mean ± SD	0.63 ± 0.75	0.86 ± 0.87	1.08 ± 0.93	1.42 ± 1.02	<0.001*
	Median (IQR)	0.00 (1.00)[a]	1.00 (1.00)[a]	1.00 (2.00)[b]	1.00 (1.00)[c]	
Sleep duration	Mean ± SD	0.95 ± 0.74	0.93 ± 0.82	1.04 ± 0.88	1.29 ± 0.88	<0.001*
	Median (IQR)	1.00 (1.00)[a]	1.00 (1.75)[a]	1.00 (2.00)[a]	1.00 (1.00)[b]	
Sleep efficiency	Mean ± SD	0.11 ± 0.41	0.40 ± 0.82	0.44 ± 0.88	0.76 ± 1.11	<0.001*
	Median (IQR)	0.00 (0.00)[a]	0.00 (0.00)[b]	0.00 (0.00)[b]	0.00 (1.00)[c]	
Sleep disturbance	Mean ± SD	0.68 ± 0.52	0.90 ± 0.45	1.05 ± 0.45	1.29 ± 0.59	<0.001*
	Median (IQR)	1.00 (1.00)[a]	1.00 (0.00)[b]	1.00 (0.00)[c]	1.00 (1.00)[d]	
Use of sleep medication	Mean ± SD	0.01 ± 0.09	0.19 ± 0.68	0.23 ± 0.70	0.34 ± 0.83	<0.001*
	Median (IQR)	0.00 (0.00)[a]	0.00 (0.00)[a,b]	0.00 (0.00)[b,c]	0.00 (0.00)[c]	
Daytime dysfunction	Mean ± SD	0.92 ± 0.90	1.09 ±0 .87	1.55 ± 0.96	1.89 ± 0.92	<0.001*
	Median (IQR)	1.00 (2.00)[a]	1.00 (2.00)[a]	2.00 (1.00)[b]	2.00 (2.00)[c]	

Results of Kruskal–Wallis/Mann–Whitney U post-hoc test with Bonferroni correction* ($p < 0.05$). Same letters indicate no statistically significant difference, while different letters indicate statistically significant differences.

Table 3
Mean (±standard deviations) and median (inter-quartile range) PSQI scores for the various TMD diagnostic groups.

Variables		No TMDs (NT)	Pain-related TMDs (PT)	Intra-articular TMDs (IT)	Combined TMDs (CT)	p-value
Global PSQI	Mean ± SD	5.00 ± 2.22	8.16 ± 4.54	6.22 ± 3.20	6.86 ± 3.73	<0.001*
	Median (IQR)	5.00 (2.75)[a]	7.00 (6.00)[b]	6.00 (4.00)[c]	6.00 (5.00)[b,c]	
Subjective sleep quality	Mean ± SD	1.70 ± 1.01	1.37 ± 0.84	1.16 ± 0.70	1.16 ± 0.74	<0.001*
	Median (IQR)	2.00 (1.00)[a]	1.00 (1.00)[b]	1.00 (0.00)[b]	1.00 (1.00)[b]	
Sleep latency	Mean ± SD	0.63 ± 0.75	1.25 ± 1.04	1.04 ± 0.93	1.14 ± 0.97	<0.001*
	Median (IQR)	0.00 (1.00)[a]	1.00 (2.00)[b]	1.00 (2.00)[b]	1.00 (2.00)[b]	
Sleep duration	Mean ± SD	0.95 ± 0.74	1.33 ± 0.89	0.96 ± 0.84	1.13 ± 0.88	<0.001*
	Median (IQR)	1.00 (1.00)[a,b]	1.00 (1.00)[c,d]	1.00 (2.00)[a]	1.00 (2.00)[b,d]	
Sleep efficiency	Mean ± SD	0.11 ± 0.41	0.84 ± 1.15	0.41 ± 0.84	0.53 ± 0.95	<0.001*
	Median (IQR)	0.00 (0.00)[a]	0.00 (1.00)[b]	0.00 (0.00)[c]	0.00 (1.00)[c]	
Sleep disturbance	Mean ± SD	0.68 ± 0.52	1.24 ± 0.58	1.00 ± 0.44	1.11 ± 0.55	<0.001*
	Median (IQR)	1.00 (1.00)[a]	1.00 (1.00)[b]	1.00 (0.00)[c]	1.00 (0.00)[b]	
Use of sleep medication	Mean ± SD	0.01 ± 0.09	0.52 ± 1.06	0.17 ± 0.59	0.26 ± 0.74	<0.001*
	Median (IQR)	0.00 (0.00)[a]	0.00 (0.00)[b]	0.00 (0.00)[a,d]	0.00 (0.00)[b,d]	
Daytime dysfunction	Mean ± SD	0.92 ± 0.90	1.60 ± 1.01	1.48 ± 0.93	1.52 ± 0.99	<0.001*
	Median (IQR)	1.00 (2.00)[a]	2.00 (1.00)[b]	1.00 (1.00)[b]	2.00 (1.00)[b]	

Results of Kruskal–Wallis/Mann–Whitney U post-hoc test with Bonferroni correction* ($p < 0.05$). Same letters indicate no statistically significant difference, while different letters indicate statistically significant differences.

Table 4
Mean (±standard deviations) and median (inter-quartile range) PSQI scores for painful TMD subtypes.

Variables		Non-painful TMDs (NP) n = 401	Myalgia (MP) n = 35	Arthralgia (JP) n = 62	Myalgia + Arthralgia (CP) n = 6	Myalgia and/or Arthralgia + Intra-articular disorders (CT) n = 341	p-value
Global PSQI	(Mean ± SD)	6.22 ± 3.20	8.49 ± 4.48	7.56 ± 4.24	12.33 ± 6.25	6.86 ± 3.73	<0.001*
	Median (IQR)	6.00 (4.00)[a]	7.00 (6.00)[b]	6.50 (4.25)[abc]	10.00 (11.50)[bc]	6.00 (5.00)[abc]	
Subjective sleep quality	(Mean ± SD)	1.16 ± 0.70	1.37 ± 0.84	1.29 ± 0.82	2.17 ± 0.75	1.16 ± 0.74	0.014*
	Median (IQR)	1.00 (0.00)[a]	1.00 (1.00)[ab]	1.00 (1.00)[ab]	2.00 (1.25)[b]	1.00 (1.00)[a]	
Sleep latency	(Mean ± SD)	1.04 ± 0.93	1.31 ± 0.93	1.15 ± 1.08	2.00 ± 0.89	1.14 ± 0.97	0.064
	Median (IQR)	1.00 (2.00)	1.00 (1.00)	1.00 (2.00)	2.00 (2.00)	1.00 (2.00)	
Sleep duration	(Mean ± SD)	0.96 ± 0.84	1.43 ± 0.85	1.27 ± 0.89	1.33 ± 1.21	1.13 ± 0.88	0.001*
	Median (IQR)	1.00 (2.00)[a]	1.00 (1.00)[b]	1.00 (1.25)[ab]	1.50 (2.25)[ab]	1.00 (2.00)[ab]	
Sleep efficiency	(Mean ± SD)	0.41 ± 0.84	0.94 ± 1.24	0.73 ± 1.07	1.50 ± 1.38	0.53 ± 0.95	0.001*
	Median (IQR)	0.00 (0.00)[a]	0.00 (2.00)[b]	0.00 (1.00)[ab]	1.50 (3.00)[ab]	0.00 (1.00)[ab]	
Sleep disturbance	(Mean ± SD)	1.00 ± 0.44	1.29 ± 0.62	1.16 ± 0.52	1.67 ± 0.82	1.11 ± 0.55	<0.001*
	Median (IQR)	1.00 (0.00)[a]	1.00 (1.00)[b]	1.00 (0.00)[ab]	1.50 (1.25)[ab]	1.00 (0.00)[b]	
Use of sleep medication	(Mean ± SD)	0.17 ± 0.59	0.51 ± 1.10	0.47 ± 0.99	1.17 ± 1.47	0.26 ± 0.74	0.001*
	Median (IQR)	0.00 (0.00)[a]	0.00 (0.00)[ab]	0.00 (0.00)[ab]	0.50 (3.00)[b]	0.00 (0.00)[ab]	
Daytime dysfunction	(Mean ± SD)	1.48 ± 0.93	1.63 ± 1.03	1.50 ± 1.00	2.50 ± 0.55	1.52 ± 0.99	0.124
	Median (IQR)	1.00 (1.00)	2.00 (2.00)	2.00 (1.00)	2.50 (1.00)	2.00 (1.00)	

Results of Kruskal–Wallis/Mann–Whitney U post-hoc test with Bonferroni correction* ($p < 0.05$). Same letters indicate no statistically significant difference, while different letters indicate statistically significant differences.

Table 5
Step-wise logistic regression analyses of predictors for poor sleep quality (PSQI ≥ 6).

	Univariate analysis			Multivariate analysis		
Variables	OR	(95% CI)	p-value	OR	(95% CI)	p-value
Age	1.009	(0.998–1.021)	0.097			
Gender	1.134	(0.804–1.600)	0.474			
TMD severity	1.038	(1.027–1.049)	<0.001*	1.038	(1.028–1.048)	<0.001*
Emotional stress	1.443	(1.034–2.015)	0.031*	0.702	(0.505–0.977)	0.036*
Parafunction	1.112	(0.825–1.498)	0.487			
Malocclusion	0.956	(0.682–1.341)	0.795			
Pain-related TMDs	3.280	(1.695–6.345)	<0.001*	3.229	(1.696–6.146)	<0.001*
Intra-articular TMDs	1.750	(1.048–2.921)	0.032*	1.909	(1.153–3.163)	0.012*
Combined TMDs	1.225	(0.864–1.737)	0.254	1.171	(0.841–1.629)	0.350

Results of logistic regression analysis* ($p < 0.05$). OR = odds ratio and CI=Confidence interval.

TMD severity (OR = 1.04; CI = 1.03–1.05). The presence of pain-related and intra-articular TMDs was most related to poor sleep.

4. Discussion

4.1. Overview and TMD prevalence

This study determined the impact of TMD severity on sleep quality and the associations between TMD diagnostic groups/pain subtypes and sleep impairments. Furthermore, the socio-demographic and TMD-related predictors for poor quality sleep were also ascertained. As sleep quality was influenced by TMD severity, diagnostic groups, and pain subtypes, the first two null hypotheses were rejected. The third null hypothesis was also duly discarded as poor sleep was partial to TMD severity and diagnostic groups. The reliability and validity of the FAI, like the PSQI, are well established [14,23,27,28]. Both measures had been utilized together in previous TMD research [22]. A global PSQI score of >6 was selected as the cut-point for poor sleep as it yielded high sensitivity and better specificity than a cut-point of >5 in Chinese samples [25].

The DC/TMD exhibited better validity than its predecessor, the Research Diagnostic Criteria for TMDs, and can be applied in both clinical and research settings [11]. It was developed based on a dual-axis biopsychosocial model with defined operationalization and provision for multiple diagnoses [29]. Based on the FAI, 89.73% of the study subjects reported the presence of TMDs. Of these, about half were diagnosed with IT (47.5%) while 40.3% and 12.2% were identified with CT and PT. In their systematic review of Research Diagnostic Criteria for TMDs (RDC/TMD) Axis I diagnoses, Manfredini et al. reported an overall prevalence of 45.3% for muscle disorders, 41.1% for disc displacements, and 30.1% for joint disorders [30]. Their findings could not be directly related to the present one as the DC/TMD applied had re-classified diagnoses into PT (embracing both muscle and joint pain) and IT (covering disc displacements and non-painful joint disorders).

4.2. Sleep quality

Studies conducted on TMD patient and community samples had supported the notion that TMDs impact sleep quality [6,22,31]. This was further corroborated by the present study which ascertained that subjects with moderate-to-severe TMDs had significantly poorer sleep quality than those with no-to-mild TMDs. Subjects diagnosed with TMDs (ie PT, IT, or CT) also reported significantly poorer sleep quality than the TMD-free controls. Furthermore, the global PSQI scores of subjects with PT was significantly higher than those with IT. Findings were consistent with those of Benoliel et al. who determined that TMD patients had poorer sleep than controls. They found higher global PSQI scores to be positively associated with features of TMDs, parafunction, co-morbid pain conditions, higher pain scores as well as poorer oral health-related quality of life [32]. Rener-Sitar et al. reported mean global PSQI scores of 7.0 for TMD patients and 5.2 for the controls. These mean scores were akin to those obtained in this study which varied from 6.2 to 8.2 for TMD patients and 5.0 for the controls [33]. The aforementioned lends support to the work of Tsai et al. recommending a global PSQI score of >6 for poor sleep [25].

While Rener-Sitar et al. reported a significant decline in sleep quality with only pain-related diagnoses, both painful and non-painful TMDs (ie PT and/or IT) were associated with significantly poorer sleep quality in this study. When the different TMD painful subtypes were compared, no significant difference in global PSQI scores was observed among subjects with myalgia, arthralgia, and combined pain. However, Kim et al. in their study on Korean TMD patients conveyed significant differences in global PSQI scores between these three TMD pain groups. Besides racial and ethnic differences, the variance could also be attributed to the diagnostic standard and protocol utilized. More studies in other Asian and Western populations are necessary before definitive conclusions can be drawn. Results of global PSQI differed considerably from that of subject sleep quality that was assessed with the question “Over the past month, how would you rate your sleep quality overall?”. The subjects with “no TMDs” actually fared worse for this item when related to those with TMDs. The use of a single inclusive statement to assess sleep quality is thus discouraged as sleep quality is a plausible multidimensional construct [34].

Multivariate regression analyses indicated that poor sleep was predicted by TMD severity as well as diagnostic groups. The probability of poor sleep was increased approximately 2–3 times by the presence of intra-articular and painful TMDs. These odds paralleled that obtained by Lei et al. based on the RDC/TMD and Self-rating Scale of Sleep (SRSS) [35]. The casual and temporal relationships between TMDs and poor sleep could not be established in this study due to the cross-sectional design employed. Sanders et al. in their prospective cohort study, determined that sleep quality deteriorates progressively ahead of painful TMD onset [36]. Moreover, this relationship was independent of confounding factors including co-morbid conditions, somatic awareness, and psychological stress. However, Yantani et al. found that poor sleep quality can be predicted by higher pain severity as well as greater psychological distress and less perceived life control in TMD patients [37]. Dubrovsky et al. explored self-reported sleep quality as a function of polysomnographic (PSG) parameters, myalgia, and depression, and concluded that poor sleep is better explained by depressive symptoms than by PSG-determined sleep disturbances or TMD-related pain [38]. The inter-relationships between chronic pain, psychological distress, and sleep, though recognized are highly complex and not well understand [39]. The three conditions share common pathophysiology and involve similar changes in

"structural and functional neurobiology" including alterations in serotonin, brain-derived neurotrophic, and other transmitter levels [39].

4.3. Sleep impairments

Ranking of sleep impairments was mostly consistent for all sleep components with subjects experiencing severe TMDs and TMD-free controls reporting the most and least decline respectively. For all sleep components, subjects with severe TMDs reported significantly higher scores when compared to all other severity categories. Those with moderate-to-severe TMDs required significantly more time to transit from wakefulness to sleep and experienced significantly more sleep disturbance as well as daytime sleepiness than the remaining two groups. The latter two symptoms are indicators of OSA and TMDs have been reported to follow OSA symptoms [19]. The association between OSA and TMDs may be mediated by SB that often occurs secondary to micro-arousals and is believed to be a "protective response" to apnea/hypopnea events [40]. More recently, Tan et al. found that only a third of OSA patients exhibited concomitant SB and these patients had significantly more sleep arousals and oxygen desaturations based on PSG [41]. All TMD subjects, irrespective of severity, reported significantly poorer sleep efficiency (ie lower proportion of time one is asleep in bed) when compared to those without TMDs. Conversely, the difference in sleep duration and use of sleep medication was insignificant among the moderate, mild, and no TMD groups.

Except for sleep duration and use of sleep medication, the PT, CT, and IT groups fared significantly worse for all sleep components when related to the control group. Subjects with pain-related and/or intra-articular disorders had significantly higher sleep latency, sleep efficiency, sleep disturbance, and daytime dysfunction scores than TMD-free ones. Most prior studies had conveyed the relationship between painful TMDs and sleep [6]. However, myalgia and arthralgia were seldom differentiated and the presence of co-morbid intra-articular disorders was hardly ever described in these studies. Arthralgia is often related to TMJ osteoarthritis and closed-lock that is associated with TMJ disc displacements [42,43]. The significant differences in sleep components between the CT/IT and NT groups were hence expected. Nevertheless, Sener et al. found no significant difference in PSQI scores between subjects with TMJ disc displacements and those with myalgia as well as controls [44]. As the aforementioned may be due to racial/ethnic differences, further studies on the connection between non-painful TMDs and sleep quality is warranted.

For painful TMD subtypes. significant differences in sleep component scores were observed only for sleep duration, sleep efficiency, sleep disturbance, and the use of sleep medication. Subjects with myalgia reported significantly shorter sleep duration, lower sleep efficiency, and more sleep disturbance than those with non-painful intra-articular TMDs. No significant difference in sleep component scores was, however, noted for subjects with only arthralgia. This observation provides further support for the plausible neurobiological mediation of orofacial muscle pain involving various combinations of peripheral afferent sensitization, central neuron hyperexcitation, and descending pain modulatory system imbalance [45]. Subjects with myalgia and arthralgia (CP) also consumed significantly more sleep medication than the non-painful TMD group. While Kim et al. determined that subjects with CP experienced significantly poorer sleep and consumed more sleep medication than those with MP and JP [15], no significant difference was observed among the various painful TMD groups in the current study. Co-morbid psychological distress together with poor quality sleep may well impel the subjects with painful TMDs to consume sleep medications [10,46].

4.4. Study limitations

Besides its inability to establish causal/temporal relationships, this study also had several other limitations. First, other sleep problems such as insomnia, sleep apnea, narcolepsy, periodic limb movement, and REM sleep behavior disorders were not ruled out. These sleep conditions are known to disrupt sleep and might influence the results of this study. Second, the sample sizes for the various TMD severity and diagnostic groups/pain subtypes were unbalanced. This arose from the simple randomization model employed where subjects who met the inclusion criteria and consented to participate were assigned to the different groups irrespective of their existing sample sizes. The uneven sample sizes had little bearing on statistical exploration as the non-parametric tests employed are based on the sum-of-ranks and no explicit assumptions were made concerning data distribution. Third, the FAI and PSQI, like other self-reported measures, are prone to response bias as subjects may exaggerate or minimize their symptoms or conditions. They are also subject to other prejudices including recall and social desirability biases [47]. While the clinical assessment of TMDs was performed with the protocolized DC/TMD, objective appraisal of sleep was not carried out. Although objective evaluation of sleep using PSG can be considered for future work, they are costly to conduct and not practical for large scale studies. Finally, the presence of other physical pain conditions that may impact sleep including lower back pain, ankylosis spondylitis, and fibromyalgia were not examined [48]. Moreover, psychosocial intermediary variables like depression, emotional, and cognitive arousals were also not explored in this study. The aforementioned should be incorporated for follow-up work given the intricate relationships between, pain, psychological distress, and sleep.

5. Conclusion

The impact of TMD severity on sleep quality and the associations between TMD diagnostic groups/pain subtypes and sleep impairments were established in this study. Subjects with moderate-to-severe TMDs were found to have significantly poorer sleep than those with no-to-mild TMDs. Similarly, subjects with pain-related and/or intra-articular TMDs also reported significantly poorer sleep than the no TMDs controls. Furthermore, those with myalgia and myalgia plus arthralgia presented significantly worse sleep than their counterparts with non-painful intra-articular disorders. Multivariate logistic regression indicated that the presence of intra-articular and pain-related TMDs increased the odds of poor sleep by two to three folds respectively. As sleep quality is compromised in TMD patients and may negatively affect treatment outcomes as well as life quality [49,50], it should be assessed routinely in clinical practice. Therapeutic interventions aimed at improving sleep might serve as useful adjuncts for more holistic TMD and orofacial pain management.

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CRediT authorship contribution statement

Adrian Ujin Yap: Conceptualization, Methodology, Supervision, Data curation, Validation, Visualization, Writing - original draft. **Ye Cao:** Methodology, Investigation, Data curation, Formal analysis,

Writing - review & editing. **Min-juan Zhang:** Methodology, Investigation, Data curation, Formal analysis. **Jie Lei:** Methodology, Investigation, Data curation. **Kai-Yuan Fu:** Funding acquisition, Conceptualization, Methodology, Supervision, Investigation, Resources, Data curation, Writing - review & editing.

Conflict of interest

The authors have no financial or personal conflict of interest to declare relating to this work.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2021.01.063.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2021.01.063.

References

[1] Finan PH, Goodin BR, Smith MT. The association of sleep and pain: an update and a path forward. J Pain 2013;14:1539–52. https://doi.org/10.1016/j.jpain.2013.08.007.

[2] Lobbezoo F, Lavigne GJ, Kato T, et al. The face of dental sleep medicine in the 21st century. J Oral Rehabil 2020;47:1579–89. https://doi.org/10.1111/joor.13075.

[3] Vanitallie TB. Sleep and energy balance: interactive homeostatic systems. Metabolism 2006;55:S30–5. https://doi.org/10.1016/j.metabol.2006.07.010.

[4] Colten HR, Altevogt BM. Sleep disorders and sleep deprivation: an unmet public health problem. Washington (DC): National Academies Press (US); 2006.

[5] Lavigne GJ, Sessle BJ. The neurobiology of orofacial pain and sleep and their onteractions. J Dent Res 2016;95:1109–16. https://doi.org/10.1177/0022034516648264.

[6] Dreweck FDS, Soares S, Duarte J, et al. Association between painful temporomandibular disorders and sleep quality: a systematic review. J Oral Rehabil 2020;47:1041–51. https://doi.org/10.1111/joor.12993.

[7] List T, Jensen RH. Temporomandibular disorders: old ideas and new concepts. Cephalalgia 2017;37:692–704. https://doi.org/10.1177/0333102416686302.

[8] Bueno CH, Pereira DD, Pattussi MP, et al. Gender differences in temporomandibular disorders in adult populational studies: a systematic review and meta-analysis. J Oral Rehabil 2018;45:720–9. https://doi.org/10.1111/joor.12661.

[9] Slade GD, Fillingim RB, Sanders AE, et al. Summary of findings from the OPPERA prospective cohort study of incidence of first-onset temporomandibular disorder: implications and future directions. J Pain 2013;14:T116–24. https://doi.org/10.1016/j.jpain.2013.09.010.

[10] De La Torre Canales G, Câmara-Souza MB, Muñoz Lora VRM, et al. Prevalence of psychosocial impairment in temporomandibular disorder patients: a systematic review. J Oral Rehabil 2018;45:881–9. https://doi.org/10.1111/joor.12685.

[11] Schiffman E, Ohrbach R, Truelove E, et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the international RDC/TMD consortium network and orofacial pain special interest group. J Oral Facial Pain Headache 2014;28:6–27. https://doi.org/10.11607/jop.1151.

[12] Bitiniene D, Zamaliauskiene R, Kubilius R, et al. Quality of life in patients with temporomandibular disorders. A systematic review. Stomatol 2018;20:3–9.

[13] Song YL, Yap AU. Outcomes of therapeutic TMD interventions on oral health related quality of life: a qualitative systematic review. Quintessence Int 2018;49:487–96. https://doi.org/10.3290/j.qi.a40340.

[14] Mollayeva T, Thurairajah P, Burton K, et al. The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: a systematic review and meta-analysis. Sleep Med Rev 2016;25:52–73. https://doi.org/10.1016/j.smrv.2015.01.009.

[15] Kim HK, Kim ME. Phenotyping 1488 patients with painful temporomandibular disorders and its relevance to subjective sleep quality: a key step for stratified medicine. Cranio 2019;29:1–11. https://doi.org/10.1080/08869634.2019.1682750.

[16] Baad-Hansen L, Thymi M, Lobbezoo F, et al. To what extent is bruxism associated with musculoskeletal signs and symptoms? A systematic review. J Oral Rehabil 2019;46:845–61. https://doi.org/10.1111/joor.12821.

[17] Jiménez-Silva A, Peña-Durán C, Tobar-Reyes J, et al. Sleep and awake bruxism in adults and its relationship with temporomandibular disorders: a systematic review from 2003 to 2014. Acta Odontol Scand 2017;75:36–58. https://doi.org/10.1080/00016357.2016.1247465.

[18] Balasubramaniam R, Klasser GD, Cistulli PA, et al. The link between sleep bruxism, sleep disordered breathing and temporomandibular disorders: an evidence-based review. J Den Sleep Med 2014;1:27–37. https://doi.org/10.15331/jdsm.3736.

[19] Sanders AE, Essick GK, Fillingim R, et al. Sleep apnea symptoms and risk of temporomandibular disorder: OPPERA cohort. J Dent Res 2013;92. https://doi.org/10.1177/0022034513488140. 70S-7S.

[20] Lee RW, Vasudavan S, Hui DS, et al. Differences in craniofacial structures and obesity in Caucasian and Chinese patients with obstructive sleep apnea. Sleep 2010;33:1075–80. https://doi.org/10.1093/sleep/33.8.1075.

[21] Faul F, Erdfelder E, Lang AG, et al. *Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175–91. https://doi.org/10.3758/bf03193146.

[22] Natu VP, Yap AU, Su MH, et al. Temporomandibular disorder symptoms and their association with quality of life, emotional states and sleep quality in South-East Asian youths. J Oral Rehabil 2018;45:756–63. https://doi.org/10.1111/joor.12692.

[23] Zhang MJ, Yap AU, Lei J, et al. Psychometric evaluation of the Chinese version of the Fonseca anamnestic index for temporomandibular disorders. J Oral Rehabil 2020;47:313–8. https://doi.org/10.1111/joor.12893.

[24] Ohrbach R, Gonzalez Y, List T, et al. Diagnostic criteria for Temporomandibular Disorders (DC/TMD) clinical examination protocol: Chinese version. https://ubwp.buffalo.edu/rdc-tmdinternational. [Accessed 15 May 2019].

[25] Tsai PS, Wang SY, Wang MY, et al. Psychometric evaluation of the Chinese version of the Pittsburgh Sleep Quality Index (CPSQI) in primary insomnia and control subjects. Qual Life Res 2005;14:1943–52. https://doi.org/10.1007/s11136-005-4.

[26] Vilanova LS, Garcia RC, List T, et al. Diagnostic criteria for temporomandibular disorders: self-instruction or formal training and calibration? J Headache Pain 2015;16:505. https://doi.org/10.1186/s10194-015-0505-9.

[27] Campos JA, Carrascosa AC, Bonafé FS, et al. Severity of temporomandibular disorders in women: validity and reliability of the Fonseca Anamnestic Index. Braz Oral Res 2014;28:16–21. https://doi.org/10.1590/s1806-83242013005000026.

[28] Topuz MF, Oghan F, Ceyhan A, et al. Assessment of the severity of temporomandibular disorders in females: validity and reliability of the Fonseca anamnestic index. Cranio (online ahead of print). doi: 10.1080/08869634.2020.1814652.

[29] Ohrbach R, Dworkin SF. The evolution of TMD diagnosis: past, present, future. J Dent Res 2016;95:1093–101. https://doi.org/10.1177/0022034516653922.

[30] Manfredini D, Guarda-Nardini L, Winocur E, et al. Research diagnostic criteria for temporomandibular disorders: a systematic review of axis I epidemiologic findings. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:453–62. https://doi.org/10.1016/j.tripleo.2011.04.021.

[31] Lei J, Fu J, Yap AU, et al. Temporomandibular disorders symptoms in Asian adolescents and their association with sleep quality and psychological distress. Cranio 2016;34:242–9. https://doi.org/10.1179/2151090315Y.0000000021.

[32] Benoliel R, Zini A, Zakuto A, et al. Subjective sleep quality in Temporomandibular Disorder patients and association with disease characteristics and oral health-related quality of life. J Oral Facial Pain Headache 2017;31:313–22. https://doi.org/10.11607/ofph.1824.

[33] Rener-Sitar K, John MT, Pusalavidyasagar SS, et al. Sleep quality in temporomandibular disorder cases. Sleep Med 2016;25:105–12. https://doi.org/10.1016/j.sleep.2016.06.031.

[34] Koh HW, Lim RB, Chia KS, et al. The Pittsburgh Sleep Quality Index in a multiethnic Asian population contains a three-factor structure. Sleep Breath 2015;19:1147–54. https://doi.org/10.1007/s11325-015-1130-1.

[35] Lei J, Liu MQ, Yap AU, et al. Sleep disturbance and psychologic distress: prevalence and risk indicators for temporomandibular disorders in a Chinese population. J Oral Facial Pain Headache 2015;29:24–30. https://doi.org/10.11607/ofph.1301.

[36] Sanders AE, Akinkugbe AA, Bair E, et al. Subjective sleep quality deteriorates before development of painful temporomandibular disorder. J Pain 2016;17:669–77. https://doi.org/10.1016/j.jpain.2016.02.004.

[37] Yatani H, Studts J, Cordova M, et al. Comparison of sleep quality and clinical and psychologic characteristics in patients with temporomandibular disorders. J Orofac Pain 2002;16:221–8.

[38] Dubrovsky B, Janal MN, Lavigne GJ, et al. Depressive symptoms account for differences between self-reported versus polysomnographic assessment of sleep quality in women with myofascial TMD. J Oral Rehabil 2017;44:925–33. https://doi.org/10.1111/joor.12552.

[39] Boakye PA, Olechowski C, Rashiq S, et al. A critical review of neurobiological factors Involved in the interactions between chronic pain, depression, and sleep disruption. Clin J Pain 2016;32:327–36. https://doi.org/10.1097/AJP.0000000000000260.

[40] da Costa Lopes AJ, Cunha TCA, Monteiro MCM, et al. Is there an association between sleep bruxism and obstructive sleep apnea syndrome? A systematic review. Sleep Breath 2020;24:913–21. https://doi.org/10.1007/s11325-019-01919-y.

[41] Tan MWY, Yap AU, Chua AP, et al. Prevalence of sleep bruxism and its association with obstructive sleep apnea in adult patients: a retrospective

polysomnographic investigation. J Oral Facial Pain Headache 2019;33:269–77. https://doi.org/10.11607/ofph.2068.
[42] Naeije M, Te Veldhuis AH, Te Veldhuis EC, et al. Disc displacement within the human temporomandibular joint: a systematic review of a 'noisy annoyance. J Oral Rehabil 2013;40:139–58. https://doi.org/10.1111/joor.12016.
[43] Lei J, Han J, Liu M, et al. Degenerative temporomandibular joint changes associated with recent-onset disc displacement without reduction in adolescents and young adults. J Cranio-Maxillo-Fac Surg 2017;45:408–13. https://doi.org/10.1016/j.jcms.2016.12.017.
[44] Sener S, Guler O. Self-reported data on sleep quality and psychologic characteristics in patients with myofascial pain and disc displacement versus asymptomatic controls. Int J Prosthodont (IJP) 2012;25:348–52.
[45] Svensson P, Graven-Nielsen T. Craniofacial muscle pain: review of mechanisms and clinical manifestations. J Orofac Pain 2001;15(2):117–45.
[46] Chisnoiu AM, Picos AM, Popa S, et al. Factors involved in the etiology of temporomandibular disorders - a literature review. Clujul Med 2015;88:473–8. https://doi.org/10.15386/cjmed-485.
[47] Althubaiti A. Information bias in health research: definition, pitfalls, and adjustment methods. J Multidiscip Healthc 2016;9:211–7. https://doi.org/10.2147/JMDH.S104807.
[48] Phelps C, Bellon S, Hinkey M, et al. Measurement properties of patient-reported outcome measures used to assess the sleep quality in adults with high prevalence chronic pain conditions: a systematic review. Sleep Med 2020;74:315–31. https://doi.org/10.1016/j.sleep.2020.06.028.
[49] Grossi ML, Goldberg MB, Locker D, et al. Reduced neuropsychologic measures as predictors of treatment outcome in patients with temporomandibular disorders. J Orofac Pain 2001;15:329–39.
[50] de Resende CMBM, de Oliveira Medeiros FGL, de Figueiredo Rêgo CR, et al. Short-term effectiveness of conservative therapies in pain, quality of life, and sleep in patients with temporomandibular disorders: a randomized clinical trial. Cranio (online ahead of print). doi: 10.1080/08869634.2019.1627068. E