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Using structural equation modeling to predict orofacial pain-related outcomes

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The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's capstone including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Marcia Vanessa Rojas-Ramirez, Student

Philip Westgate, PhD, Committee Chair

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CAPSTONE FOR MASTER IN PUBLIC HEALTH

Using structural equation modeling to predict orofacial pain-related outcomes

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July 20th, 2017

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Abstract

Objectives: To test if the structure of a proposed theoretical model comprised of specific observed variables clustered to measure three latent variables of anxiety, depression, and fatigue exhibited good global fit with the observed data and had adequate reliability using confirmatory factor analysis (CFA). A secondary objective was to use structural equation modeling (SEM) to test the direct effect of the latent variables of depression, anxiety, and fatigue on orofacial pain outcomes.

Methods: Subjects were evaluated and treated at an orofacial pain clinic between 2009 and 2014. Those who completed a battery of psychosocial and pain-related questionnaires were invited to participate in an online survey assessing pain outcomes 3-8 years later.

Results: Of 1499 eligible participants that were invited to complete the online survey, 280 provided complete data. Of those, 27% were no longer having an orofacial pain complaint. The initially proposed model structure was modified due to misspecifications. The modified model exhibited adequate global fit indexes (χ^2= 111.54 (47), .001, RMSEA = .07 (.053, .087), CFI =.971, SRMR=.495) and acceptable measures of reliability. None of the proposed predictors of the modified model had a direct effect on pain outcomes (p>.05) in the SEM analysis.

Discussion: The findings suggest that neither fatigue nor psychological factors were significant predictors of orofacial pain outcomes. Approximately 75% of the participants continued to have an orofacial pain complaint. Future research should explore if these associations are sample-, diagnosis-, or gender-specific.

1. Background

Overview of Chronic Orofacial Pain

Chronic orofacial pain conditions are characterized by pain in the head or face[1] that have persisted beyond 3 months.[2] Orofacial pains can be of muscular, neuropathic, intracapsular, centrally-maintained, neurovascular, or multiple origins. Relative to other chronic pain conditions, orofacial pains are thought to be more distressing for patients because they interfere with talking, eating, and expressing emotions.[3] Orofacial pains have an estimated lifetime prevalence of approximately 22% in the general population[4] and are associated with lost productivity and substantial medical expenses, as well as increase in compensations for disability.[1] They are also associated with worse psychosocial functioning,[5] which may in turn exacerbate pain and diminish recovery. Yet, relatively little is known about how psychosocial functioning can influence long term pain outcomes in chronic orofacial pains.

Psychosocial Contributors to Chronic Orofacial Pain

Depression, anxiety, and fatigue are psychosocial conditions associated with higher pain intensity, longer pain duration, worse physical functioning, and greater disability in patients with chronic lower back pain, fibromyalgia, cancer pain, and diabetic neuropathy.[6-10] In the orofacial region, Ohrbach and Dworkin[11] performed a five year follow-up with 234 TMD patients and found that patients with elevations in depression or anxiety exhibited worse pain trajectories. Another study found that psychological distress was associated to persistent pain four years later,[12] and a more recent study found that high levels of pain-related disability were associated with higher depression, somatization, and pain intensity in TMD patients.[13] Yet, literature linking psychosocial functioning to worse

pain outcomes in orofacial pains is limited by relatively few studies,[12, 14-18] with the majority of them using a temporomandibular disorder (TMD) sample, which compose only a part of orofacial pains. These studies are often cross-sectional, providing just a snap-shot of the associations. As such, assessing the relationship of depression, anxiety, and fatigue on orofacial pains beyond TMD could bring further insight on pain outcomes.

Depression as a Predictor

Numerous studies have demonstrated high rates of comorbidity between orofacial pain and depression.[14, 19-22] Cross-sectionally, depression is positively associated with pain intensity, pain unpleasantness, pain interference, and disability in orofacial pain samples.[7, 8, 23] A longitudinal study in TMD found that premorbid depression was associated with greater disability and higher depression scores at follow-up.[14] However, this study had a low response rate (19%) and high variability between the initial evaluation and follow-up.

Anxiety as a Predictor

Increasing attention is being given to anxiety as a predictor of pain outcomes in orofacial pain conditions. A study found that approximately half of college students with orofacial pain also reported significant symptoms of anxiety.[24] Nevertheless, there are inconsistent results regarding elevations of anxiety in these samples[25] that could be associated to dissimilarities in the referent groups.

Post-traumatic stress disorder, a disorder characterized by severe anxiety following trauma exposure, has been consistently linked with greater pain intensity and disability in orofacial pain patients,[26-30] suggesting that anxiety can be triggered by distinct factors and may play a role in the maintenance of orofacial pains. However, limited work has examined the predictive value of anxiety on orofacial pain outcomes longitudinally.

Fatigue as a Predictor

Like anxiety, fatigue has recently been viewed as an important psychophysiological predictor of pain outcomes for chronic orofacial pains. de Leeuw and collaborators found considerably higher general fatigue symptoms in a sample of orofacial pains compared to healthy controls.[31] Differences have also been found for emotional and mental fatigue.[31-33] Two different studies from Boggero and collaborators demonstrated that the relationship between psychosocial distress and pain interference was partially mediated through fatigue[34] and that total fatigue predicted pain interference above and beyond depression, sleep disturbance, psychosocial distress, or pain intensity.[35] Fatigue may thus be an important psychosocial predictor for pain outcomes.

In summary, the available cross-sectional scientific literature suggests that depression, anxiety, and fatigue are associated with pain outcomes. Thus, exploring if these associations remain significant over time is an important area for research. The present study will attempt to replicate and extend the available findings by using a larger sample, having less variability in time between initial evaluation and follow-up, and using greater variability in orofacial pain diagnoses. Additionally, it will use longitudinal data and structural equation modeling (SEM) to examine these relationships.

SEM uses observable variables (i.e., continuous or categorical variables that are measured and collected during studies, such as weight) and latent variables (i.e., hypothetical constructs that reflect an event that is not directly observable nor fully measurable, such as depression). When observable variables are used to measure constructs, they are called indicators. When statistical procedures are used in the analysis of a construct, they are called factors. SEM is not a single statistical analysis but a combination of regression

analysis of observable variables and factor analysis of latent variables. Additionally, SEM has another type of latent variable: the residual or error term. If these error terms are associated to observed variables, they represent the amount of variance that is not explained by the latent construct and indicate random measurement error or score unreliability.

SEM is used to test theories, and allows for causal inference by analyzing patterns of variance and covariance in the data.[36] SEM is usually preceded by Confirmatory Factor Analysis (CFA). In CFA, the structure of a theoretical model is statistically tested to determine if it is a good fit for the observed data. It tests the hypothesis that there is a relationship between the observed variables and the proposed latent variables. In the current study we aimed to first use CFA to test the structure of a model that was derived from theory, followed by the use of SEM to predict pain outcomes. These statistical methods were particularly attractive for this study because we hypothesized that distinct observed variables could be clustered to measure specific latent variables of depression, anxiety, and fatigue, and that these later factors could predict pain outcomes.

2. Aims and Hypotheses

The proposed project had the following aims.

Aim 1: To test if the structure of the proposed theoretical model (observable and latent variables) exhibit good global fit for the observed data and had adequate reliability using CFA.

Hypothesis1: The proposed model structure will exhibit adequate model global fit for the observed data and good reliability.

Aim 2: To use SEM to test the direct effect of depression on orofacial pain outcomes.

Hypothesis 2: Depression will have a significant direct effect on orofacial pain outcomes.

Aim 3: To use SEM to test the direct effect of anxiety on orofacial pain outcomes.

Hypothesis 3: Anxiety will have a significant direct effect on orofacial pain outcomes.

Aim 4: To use SEM to test the direct effect of fatigue on orofacial pain outcomes.

Hypothesis 4: Fatigue will have a significant direct effect on orofacial pain outcomes.

Pain outcomes were defined as: pain intensity, pain unpleasantness, pain interference, and pain-related disability at follow-up.

Aims 2, 3, and 4 were tested controlling for age, pain duration, pain intensity, and pain unpleasantness at the initial evaluation.

3. Study Design

This study used a combination of retrospective and prospective methodologies. It included participants who sought treatment at the Oral and Facial Pain Clinic at the University of Kentucky (UK) between the years 2009 through 2014 (Time 1). To be eligible for study inclusion, participants had to provide psychosocial and pain information and undergo a thorough clinical evaluation to determine diagnoses, followed by a treatment plan proposal. Eligible participants at Time 1 were invited to participate in an online survey (Time 2) which assessed for pain outcomes (pain intensity, pain unpleasantness, pain interference, and pain-related disability). Compensation in the form of a $10 check was offered to those who participated in the online survey. This study was approved by the Institutional Review Board of UK (16-0643-P3K).

4. Materials and Methods

Power Analysis

A prior power analysis was conducted to determine the required sample size to detect the associations between psychosocial predictors and pain outcomes. Power analysis for structural equation modeling is influenced by 1) the anticipated effect size, 2) the desired power, 3) the number of latent variables, 4) the number of observed variables, and 5) the significance level. ***Table 1*** demonstrates the sample size calculations for small, medium, and large effects sizes. Based on these input values, it was determined that a minimum of 200 participants would be needed to reach an admissible solution and 239 would be needed to detect small effects. We aimed to obtain at least 250 participants anticipating missing or incomplete data.

Data Collection

Participants who were seen at Time 1 were identified. Their information was accessed to determine whether they completed the battery of psychosocial and pain questionnaires described below. Only those individuals who completed these questionnaires were eligible for participation at Time 2. The study was divided in 3 phases based on the years of initial evaluation: **Phase I (2009-2010), Phase II (2011-2012), and Phase III (2013-2014).** The same procedures were performed in each of the phases as follows. **A).** A letter with a unique person-specific alphanumeric code was sent to each eligible participant explaining the purpose of the study and instructions for participation. **B).** To access the online survey, participants were required to input the given code so the new information could be linked to the information of the initial visit. **C).** After the invitation letter was mailed, participants

had 6 weeks to answer the survey. Two reminder letters were sent at week 3 and 5. **D).** Once the information was merged for each participant, the data were de-identified.

Battery of Time 1 Questionnaires

a) Depression latent variable. A latent variable was created from subscales of three measures. The *Symptom Check List-90-Revised (SCL-90R),*[37] was used to asses psychosocial functioning in chronic pain patients during the past 7 days. Only the depression subscale of the SCL-90R was used. It contained 13 items and demonstrated strong reliability and validity in previous research.[37-39] The *West Haven Yale Multidimensional Pain Inventory (WHY-MPI)*[40] was used to assess psychosocial functioning along 12 independent domains. Only the affective distress subscale was used. It contained 3 items and was designed to measure pain's impact on mood. Previous research has validated this measure as a proxy for depression in orofacial pain samples.[41, 42] Finally, the *Satisfaction with Life Scale (SWLS),*[43] was used to measure the extent to which participants reported satisfaction with their life. This is a 5 items questionnaire and the total score was used for this study.

b) Anxiety latent variable. A latent variable was created from subscales of two measures. The anxiety subscale of the *SCL-90R* contained 10 items and is well-established for assessing psychosocial functioning in chronic orofacial pain populations.[37, 44, 45] The life control subscale of the WHY-MPI contained two items and has been validated as a measure of anxiety.[41, 42, 46]

c) Fatigue latent variable. The *Multidimensional Fatigue Inventory Short Form (MFI-SF)* is a 30-item questionnaire assessing fatigue symptoms over the past week.[47] Four subscales were used: general fatigue, physical fatigue, emotional fatigue, and mental

fatigue. Previous research has established the validity of the subscales in clinical populations, and subsequent work has replicated these findings using CFA techniques.[48, 49]

d) Demographics. Age, gender, and primary diagnosis were collected to describe the sample.

Battery of Time 2 Questionnaires

a) Pain Outcomes. Pain outcomes were assessed using the *Numerical Rating Scale (NRS)* of pain intensity, which asked participants to grade their average pain using a scale that ranged from 0 to 10, with anchors of "No pain at all" to "The worst pain you can imagine." The *Pain Unpleasantness Scale (PUS),* asked participants to represent how unpleasant their pain experience was by placing a mark on a 100-mm line with anchors of "Not at all disagreeable" to "The most disagreeable pain you can imagine," resulting in a possible score of 0-100. Additionally, pain interference was assessed using the pain interference subscale of the *WHY-MPI,* which included 9 items and measured the extent to which pain disrupted vocational, social/recreational, and family/marital functioning.[46] Finally, pain-related disability was assessed using the *Chronic Pain Graded Scale (CPGS),*[50] which contained 10 items assessing the intensity, disability, and impairment associated to pain.

b) Demographics. Race, education, marital and employment status were collected to describe the sample.

Statistical Analysis Plan

Data screening was performed prior to data analysis. Descriptive statistics were used to describe the sample. Participants were classified as having or not pain at Time 2. Comparison between the two groups was done by Chi-square tests (for categorical variables) and independent t-tests (for continuous variables). CFA was used to test if the

proposed theoretical model structure was correctly specified and to statistically validate the reliability of the individual factors. To evaluate the factor loadings, which are a measure of the validity of the observed variables, the following rules of thumb were used: loadings above 0.71 are excellent, those above 0.63 are very good, those above 0.55 are good, those above 0.45 are fair, and those at or above 0.32 are poor.[51] SEM analysis was used to determine predictability of pain outcomes by the latent variables of depression, anxiety, and fatigue (see ***Figure 1)***. Significance level was set at .05. The estimation method used for the CFA and SEM analyses was maximum likelihood (ML).

Model global fit testing for CFA and SEM was determined by using a combination of indexes that represent generally accepted thresholds. The Exact Fit Index measures the discrepancy between the data's variance/covariance pattern and that of the model being tested. The chi-square test was used for this index, and the goal is to fail to reject the null hypothesis ($p \geq .05$), showing that there is no difference between the covariance predicted by the model and the one observed in the data. Approximate Fit Indexes do not involve significance tests, and are defined as an acceptable range for model-data correspondence. The root mean square error of approximation (RMSEA)[52] is an absolute fit index used to measure how close the model fitted the data, and estimates the amount of error approximation per model, taking sample size into consideration for its calculation. It has been proposed that RMSEA $\leq .05$ indicate "good fit." The comparative fit index (CFI)[53] is an incremental fit index that measures the degree to which the tested model accounts for the variance in the data. It has been proposed that the threshold for "good fit" involves values $\geq .90$. The standardized root mean square residual (SRMR) is another absolute fit that measures the overall difference between the observed and predicted correlations. It has

been suggested that values ≤.08 are indicative of "acceptable fit." To compare initial and final models, the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) were used. Smaller values in these measurements indicate a better model.

To determine model classification and specification the guidelines proposed by Kenny, Kashy, and Bolger were used.[54] The data matrix analyzed in the SEM was the covariance matrix, and results aimed to obtain a positive definitive matrix (is nonsingular, has positive eigenvalues, and no out-of-bounds values for correlations or covariances).[36] The statistical software AMOS was used for CFA and SEM analyses (Arbuckle, J. L. (2016). Amos (Version 24.0) [Computer Program]. Chicago: IBM SPSS).

5. Results

Part A: Data Screening and Descriptive Statistics

From the 1499 individuals that were invited to participate in the study at Time 2, 288 completed the online survey, giving a response rate of 21.4% (see ***Figure 2)***. Eight subjects were removed from analysis because they were missing more than 20% of data. A final sample size of 280 participants was used for both CFA and SEM analyses. The remaining data had 1.6% of total values missing. Little's Missing Completely at Random (MCAR) test was non-significant [χ^2= 122.47(131), p=.690]; therefore, missing values were imputed using the expectation-maximization algorithm.

All variables of interest followed an approximately normal distribution using the criteria of +/-3 in the Skewness Index, and were linearly associated to the outcomes of interest. Influential outliers were tested using the Cook's Distance Analysis. None of the

observations had values above .06. Multicollinearity was tested using the Variance Inflation Factor (VIF). All values in the data were equal to or less than 3 with Tolerance coefficients smaller than .1. Satisfaction with life and life control scales were reverse scored so that higher scores represented worse functioning on all variables.

Table 2 presents the descriptive statistics of the final sample. Of the 280 individuals 27% (n=75) of them had no pain at Time 2. The sample self-identified predominantly as female (86%), White/Caucasian (98%), married (76%), mainly full-time workers (39%), with an education level of any post-graduate studies (39%). Those with no pain at Time 2 were more likely to be older, report less pain duration at Time 1, have less intense and unpleasant initial pain, and have better psychosocial profile than those with pain at Time 2.

Part B: Confirmatory Factor Analysis (CFA)

Aim 1 was to test if the structure of the proposed theoretical model exhibited good global fit for the observed data and had adequate reliability using CFA. In this first analysis, we explored if the indicator variables could be grouped under three factors: Depression, Anxiety, and Fatigue (initial CFA model, see ***Figure 3***). However, the interfactor correlations between anxiety and fatigue (r=1.02), and anxiety and depression (r=1.14) produced an inadmissible solution involving correlations outside the plausible range that interfered with model fitting. See ***Table 3*** for standardized factor loadings and ***Table 4*** for global model fit indexes. Poor model fit of the initial model is very common in CFA, and calls for theory-driven model re-specifications.[36]

After re-specifications, a new model was identified. See ***Figure 4.*** The model was improved using the Modification Index presented in the output display of AMOS. The

modifications to the new CFA model included the combination of anxiety and depression into one factor (psychological factor) using the new observable variable: psychological distress. It also incorporated a pain outcome latent factor that was composed by pain intensity, pain unpleasantness, pain-related disability, and pain interference at Time 2. Finally, it included four error correlations. Combined, all these modifications achieved sufficient model identification and specification.

The modified CFA model was classified as recursive since the causal effects were strictly unidirectional, and as a Non-Standard CFA model because it included error correlations.

Additionally, all standardized loadings were classified as good, very good, or excellent, with values that ranged from 0.56 to 0.95 and all were statistically significant ($p<.001$). See ***Table 5.*** Coefficients of determination represent how much of the variance of each observed variable was explained by its latent factor. The highest coefficient of determination for the psychological factor was psychological distress (.81), implying that the psychological factor accounted for 81% of the variance in psychological distress. Similarly, the highest coefficient of determination for the fatigue factor was emotional fatigue (.63), implying that the fatigue factor accounted for 63% of the variance in emotional fatigue. Likewise, the highest coefficient of determination for the pain outcome factor was pain-related disability (.95), implying that the pain outcomes factor accounted for 95% of the variance in pain-related disability at Time 2. See ***Table 5.*** Overall, the coefficients of determination explained by each factor indicated that each of the observed variables were related to the hypothesized latent variables.

Model global fit testing is presented in ***Table 6.*** With the exemption of the chi-square test, the remaining model fit indexes were within the acceptable range for an “adequate model.”

The AIC and BIC values are much smaller for the final model than they were for the initial model, suggesting the superiority of the final model. The interfactor correlations were r = .97 between the psychological and fatigue factors, r = .36 between the psychological and pain outcome factors, and r = .30 between the fatigue and pain outcome factors. All interfactor correlations were statistically significant (p= <.001), suggesting that the three dimensions were related, as initially hypothesized.

The final model exhibited adequate reliability demonstrated by all composite reliability (CR) scores being >.7. There was also convergent validity demonstrated by all the Average Variance Estimator (AVE) scores being >.5, but there were discriminant validity issues since the square root AVE for the psychological and fatigue factors were lower than the interfactor correlation. This was expected considering the high correlation between these two factors (see ***Table 7)***.

The Pearson correlations of all the variables included in the final CFA model are presented in ***Table 8*****.** Most correlations were statistically significant (p< .01). The highest correlation was observed between pain intensity and pain unpleasantness at Time 2 (r= .85).

Part C: Structural Equation Modeling (SEM)

Aims 2 and 3 were initially designed to use SEM to test if a significant direct effect was seen between depression and anxiety factors on pain outcomes. Due to model re-specifications to improve the global fit, these hypotheses were modified so that the new model tested if a significant direct effect was seen between the psychological and pain outcome factors. Aim 4 remained unchanged, to test if a significant direct effect was seen

between the fatigue and pain outcome factors. Both aims were tested controlling for age, pain duration, pain intensity and unpleasantness at Time 1. See ***Figure 5.***

The theoretical model tested in this study was a fully latent model, since the structural part involved only latent variables with multiple indicators.[36] The estimation for this final model converged and produced an admissible solution.

Based on results showed on ***Table 9***, the global fit of this model was adequate for all the indexes besides the chi-square. ***Table 10*** presents the regression coefficients for the structural part of the SEM. In contrast to our hypotheses, the psychological and fatigue factors did not predict pain outcomes in this sample. Specifically, no significant direct effects were seen from the latent factors on the outcome. From the four controlling variables at Time 1 (age, pain duration, pain intensity and unpleasantness), only pain intensity was not significantly associated to pain outcomes at Time 2 (p=.704). Interpretation of the standardized regression coefficients suggested that for every standard deviation increase in pain unpleasantness, there was a significant .18 standard deviation increase in pain outcomes (p= .022). For every standard deviation increase in age, there was a significant .14 standard deviation decrease in pain outcomes (p= .030). For every standard deviation increase in pain duration, there was a significant .22 standard deviation increase in pain outcomes (p=.004). Overall, the final model was retained since it was parsimonious, had acceptable correspondence to the data, and made theoretical sense.

6. Discussion

The results of this study did not support the first hypothesis regarding the exact composition of the CFA model. The structure of the CFA model was altered due to

misspecification errors. The final model used the same variables with the exemption of anxiety and depression, which were combined into one single composite. The chi-square test was significant in both CFA and SEM models. However, one of the main limitations of this test is that it is highly influenced by sample size. In the current study, we used 280 participants, which increased the likelihood of obtaining a significant p-value. Thus, RMSEA, CFI, and SRMR are supporting indexes of goodness of fit for the current data. The factor loadings and coefficients of determination in this final CFA model implied that each variable was important and contributed in different ways to the latent factors. Nevertheless, the interfactor correlation between psychological and fatigue was high, suggesting that either they could have been measuring a similar construct, or it could have reflected similarity in the measurement method. Specifically, the observed variables that composed each of these two factors were all from self-reported questionnaires completed by participants on the same day. When this homogeneity in measurements occurs, it increases the risk of having common method variance (CMV), which in turns could cause interfactor correlations to be inflated. Consequently, future research should use different measurement methods (i.e., behavioral observation, diagnostic interview, clinical/physiological, and self-report) to reduce the possibility of increasing CMV bias.

Additionally, the results of this study did not support hypothesis 2 of a direct effect between the psychological and pain outcome latent factors. Similarly, they did not support hypothesis 3 of a direct effect between the fatigue and pain outcome factors. It could be that the potential effect of CMV in CFA was carried over to the SEM and interfered with the results. Future work should also examine the effects of other potentially influential factors such as treatment, gender, diagnosis, and natural course of disease.

Finally, every time a mail survey methodology is implemented, the risk of low response rates and nonresponse bias is inherent. This study used a similar methodology to the one that was proposed by Dillman,[55] where an invitation letter was sent to participants followed by reminder letters. The main difference between our survey and the one implemented in other studies is that we requested participants to fill out an online survey instead of a printed survey with an addressed return envelope. Doing so could have decreased our opportunity of achieving a higher response rate, since participant response was limited by computer skills and internet availability. One way to address this methodology issue in the future would be to use a two-method survey, where the online survey as well as the printed version are implemented at different stages of the study. This method could minimize the expenses of printing and postage while still allowing the researcher to obtain a wider access to information and possibly increase response rates.

Even though the response rate in the current study (21.4%) was lower than what was reported in other studies,[56,57] we compared demographics, psychosocial and pain characteristics at Time 1 of those who completed the online survey to those who were invited but did not participate. The only significant difference was that those who participated in the study were older than those who did not ($p<.05$). Thus, those who participated in the current study appeared to be representative of the initial targeted sample.

Strengths and Limitations

This study has important strengths. First, it used longitudinal data to provide information regarding pain outcomes in orofacial pains. Second, SEM allowed us to remove measurement error in psychological and fatigue concepts, providing results that may be more representative of the real association between predictors and outcomes. Third, it used

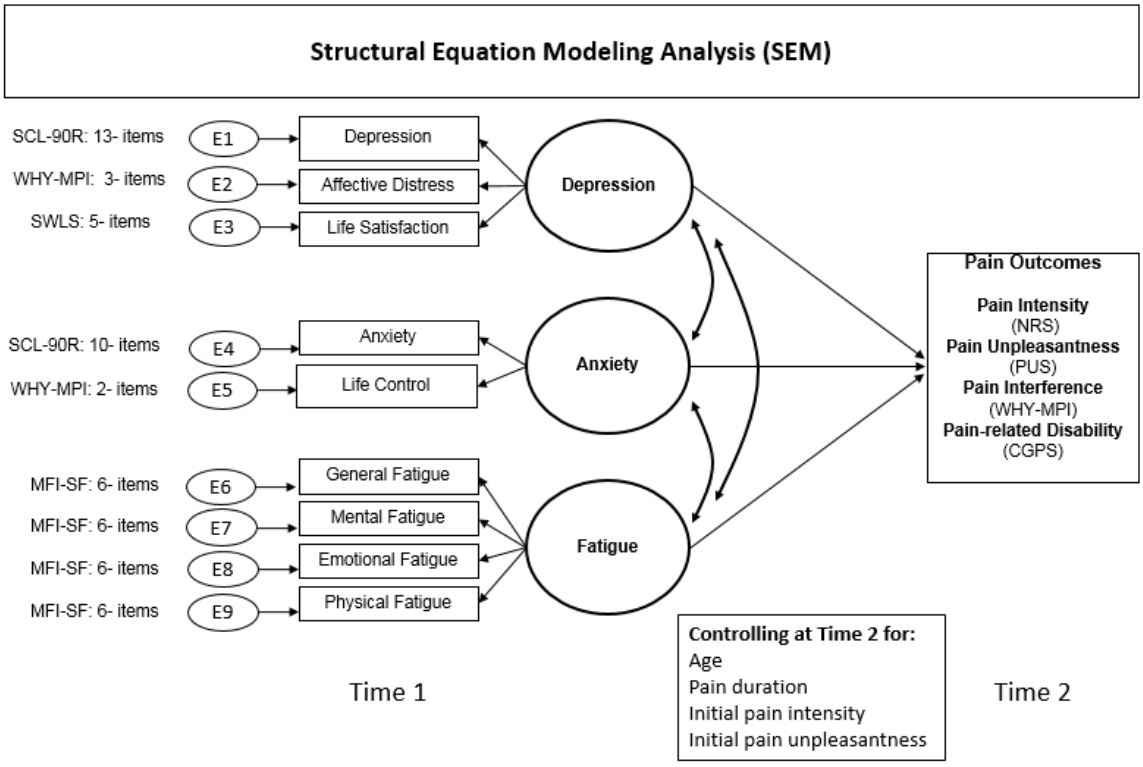
a bigger sample size than other studies, allowing the detection of smaller effects. Finally, it included different orofacial pain diagnoses, allowing for greater generalizability. On the other hand, this study also has limitations. First, it used a single measurement method that may have introduced CMV bias. Second, since part of this study was retrospective, measures of important variables could not be included in the Time 1 questionnaires. Third, the use of an online survey yields a low response rate. Finally, the use of complex methodology such as SEM required the judgment of the researcher in determining whether the model was "acceptable" enough, introducing a higher-level perspective to the analysis and interpretation or in some cases subjectivity. Thus, replication of the results by other researchers is critical to the validity of the proposed model.

Conclusions

This study showed that by using a more complex statistical technique we produced an acceptable model to test if psychological and fatigue concepts predicted pain outcomes. However, results indicated that neither of these two concepts could predict the targeted outcome. The results confirmed the strong association between the concepts of fatigue, psychological factors and pain outcomes. Future research should explore if these associations are sample-, diagnosis-, or gender-specific.

7. Tables and Figures

Figure 1. Hypothetical SEM predicting pain outcomes.



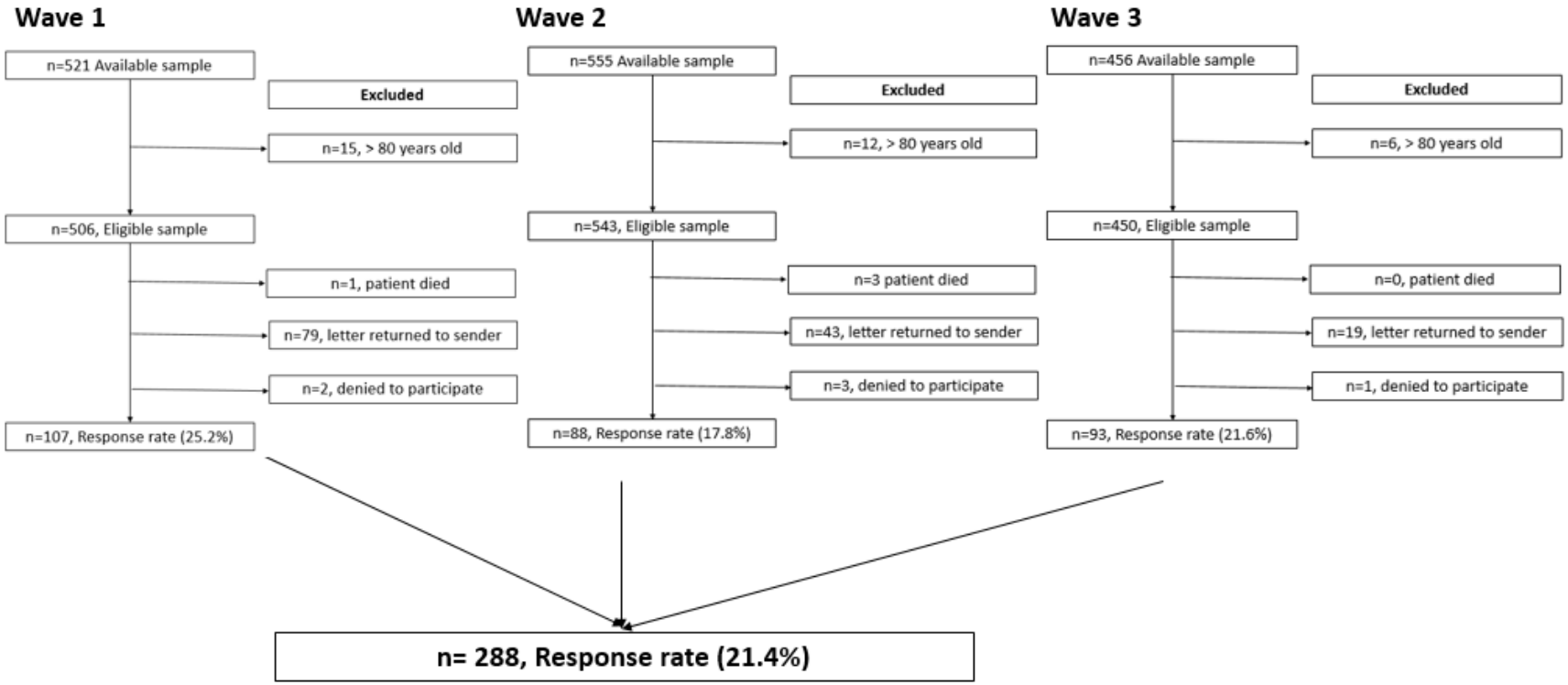
Abbreviations: SCL-90R, Symptom Check List-90-Revised, WHY-MPI, West Haven Yale Multidimensional Pain Inventory, SWLS, Satisfaction with Life Scale, MFI-SF, Multidimensional Fatigue Inventory Short-Form, NRS, Numerical Rating Scale, PUS, Pain Unpleasantness Scale, CPGS, Chronic Pain Graded Scale, E, Error term.

Nomenclature: Circles indicate the three latent variables: depression, anxiety and fatigue. The rectangles are the indicator variables. Curve arrows indicate correlations between the latent variables. Straight lines represent direct effects between latent variables and pain outcomes.

Table 1. Sample size calculations for small, medium, and large effects sizes for 3 latent variables and 9 observed variables at a probability level of .05.

Anticipated Effect Size	**Statistical Power**	**Sample Size**
0.11 (small)	0.80	239
0.3 (medium)	0.80	200
0.5 (large)	0.80	180

Figure 2. Description of study sample selection.



Abbreviations: n, sample size.

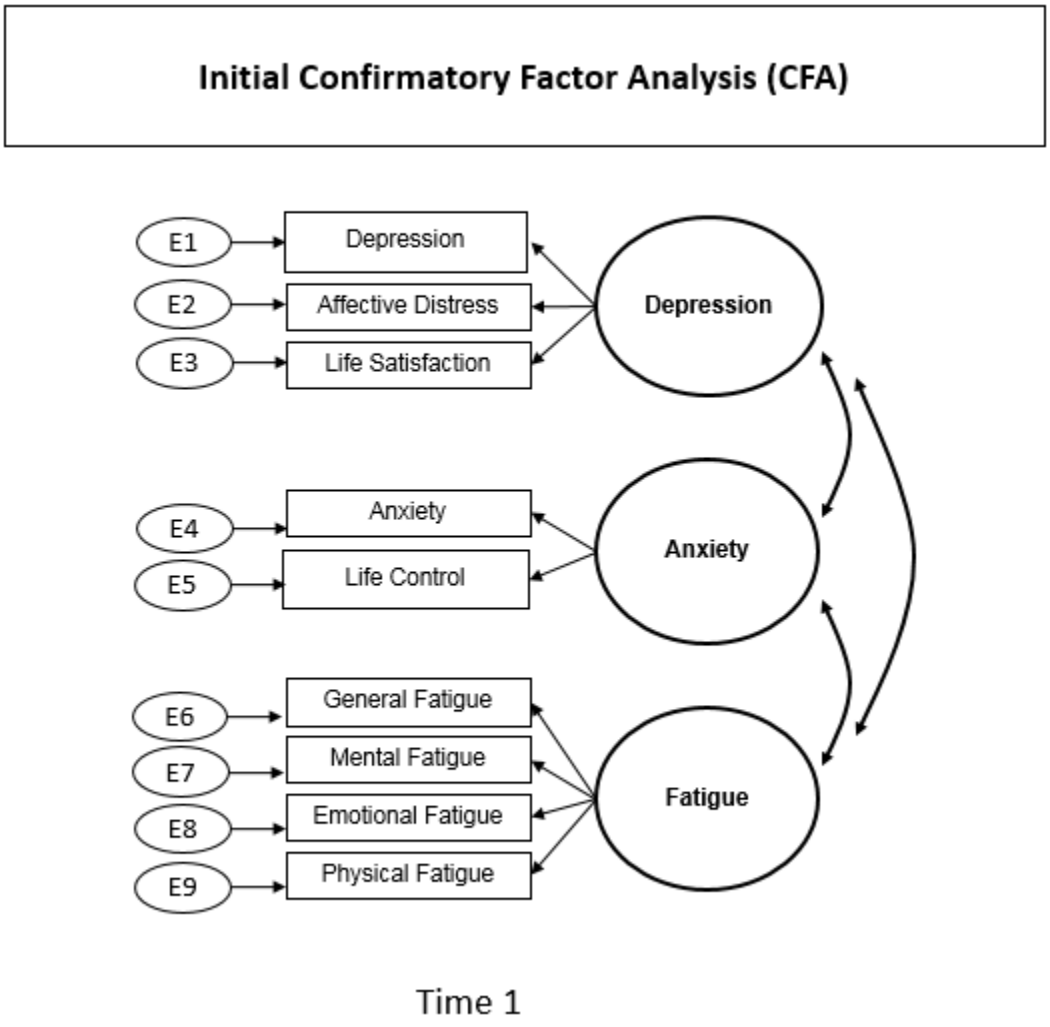
Table 2. Descriptive Statistics. Descriptive statistics by pain presence at follow-up. Means and standard errors (in parentheses) are given for continuous variables, whereas frequencies and column percentages (in parentheses) are given for categorical variables.

	No Pain at FU| n=75	**Pain at FU| n=205**	***p*-value**
Gender			
Male	17 (22.7%)	23 (11.2%)	**.015**
Female	58 (77.3%)	182 (88.8%)	.
Race			
White/Caucasian	72 (96.0%)	202 (98.5%)	.194
Other	3 (4.0%)	3 (1.5%)	.
Marital Status			
Single	9 (12.0%)	26 (12.7%)	.938
Married	59 (78.7%)	155 (75.6%)	.
Widowed	1 (1.3%)	6 (2.9%)	.
Divorced	5 (6.7%)	16 (7.8%)	.
Refused	1 (1.3%)	2 (1.0%)	.
Education Level			
Missing data	0	1 (0.1%)	.735
Grades 12/GED/or less	11 (14.7%)	27 (13.2%)	.
Some college/Associates degree	22 (29.3%)	54 (26.5%)	.
Bachelor's degree	12 (16.0%)	45 (22.1%)	.
Any post-graduate studies	30 (40.0%)	78 (38.1%)	.
Employment Status			
Missing data	0	1 (0.1%)	**.008**
Full-time	34 (45.3%)	80 (39.2%)	.
Part-time	5 (6.7%)	30 (14.7%)	.
Disability/Unable to work for health reasons	1 (1.3%)	26 (12.7%)	.
Unemployed	7 (9.3%)	18 (8.7%)	.

	No Pain at FU| n=75	**Pain at FU| n=205**	***p*-value**
Retired	28 (37.3%)	50 (24.5%)	.
Diagnoses Classification			
Missing data	11 (0.1%)	11 (0.1%)	**.002**
Muscle Related	17 (26.6%)	82 (42.2%)	.
Inter/Intra articular	28 (43.7%)	41 (21.1%)	.
Neuropathic	9 (14.1%)	46 (23.7%)	.
Other Diagnoses	10 (15.6%)	25 (12.9%)	.
Age	54.00 (1.34)	48.21 (0.94)	**.001**
Pain Duration	24.89 (4.78)	83.43 (8.20)	**<.0001**
Pain Intensity Time 1	38.11 (2.74)	48.66 (1.72)	**.002**
Pain Unpleasantness Time 1	48.03 (3.28)	59.53 (1.91)	**.002**
Affective Distress	42.85 (1.65)	46.76 (0.98)	**.041**
Life Control	38.10 (2.04)	40.40 (1.18)	.321
Psychological Distress	52.54 (1.42)	57.50 (0.64)	**.001**
Satisfaction with Life	14.13 (0.67)	15.70 (0.47)	.073
Emotional Fatigue	5.20 (0.63)	6.05 (0.38)	.251
General Fatigue	7.23 (0.69)	9.90 (0.48)	**.003**
Mental Fatigue	4.44 (0.53)	5.57 (0.35)	.092
Physical Fatigue	3.55 (0.53)	5.52 (0.36)	**.004**
Pain Intensity Time 2	0	4.14 (0.15)	**<.0001**
Pain-related Disability Time 2	0	1.81 (0.06)	**<.0001**
Pain Unpleasantness Time 2	0	42.14 (1.70)	**<.0001**
Pain Interference Time 2	0	2.00 (0.11)	**<.0001**

Chi-square tests were used to compare categorical variables and independent t-test were used to compare continuous variables.

Figure 3. Graphical representation of the initial CFA model.



Abbreviations: E, error term.

Nomenclature: Circles indicate the three latent variables: depression, anxiety and fatigue. The rectangles are the indicator variables. Curve arrows indicate correlations between the latent variables. Straight lines represent direct effects.

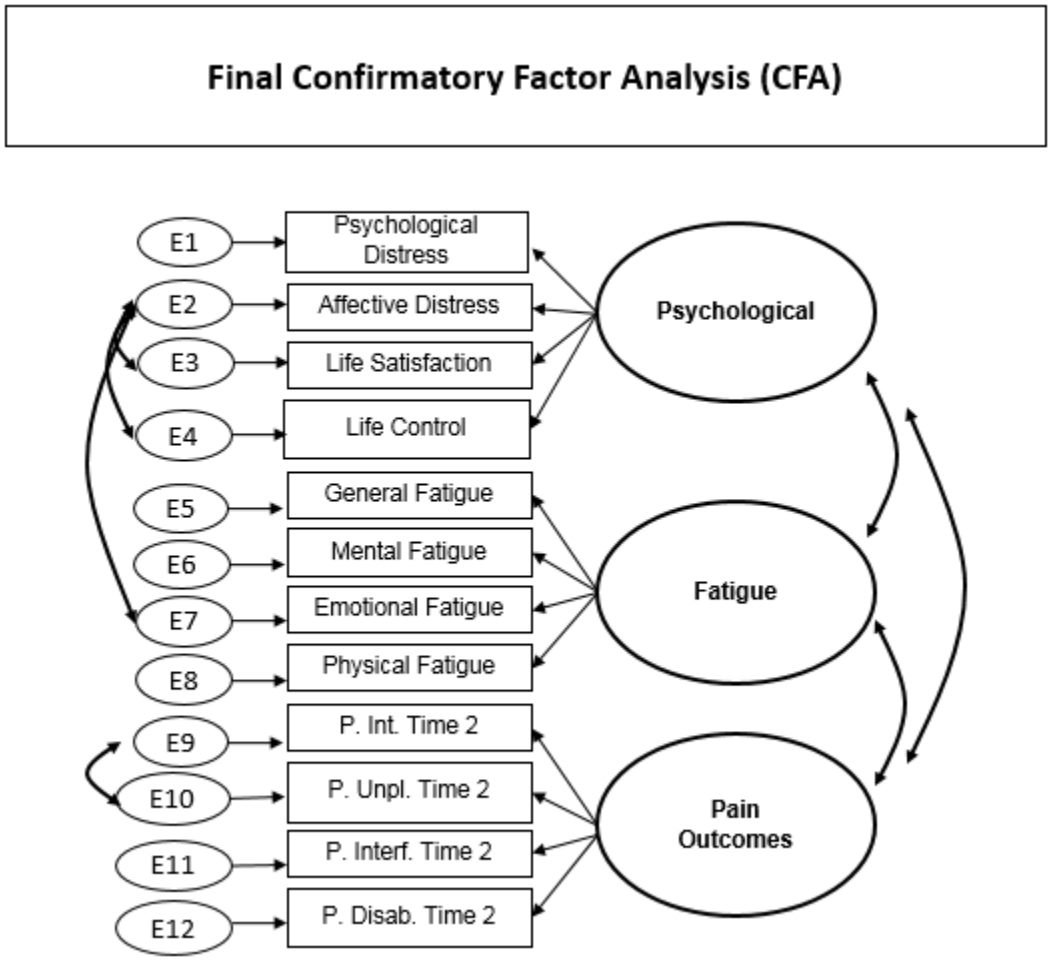
Table 3. Standardized factor loadings for the initial CFA model.

Latent Variables	Observed Variables	Standardized Factor Loadings
Depression		
	Depression	.85
	Affective Distress	.68
	Satisfaction with Life	.55
Anxiety		
	Anxiety	.77
	Life Control	.59
Fatigue		
	General Fatigue	.75
	Mental Fatigue	.80
	Emotional Fatigue	.88
	Physical Fatigue	.69

Table 4. Global model fit indexes for the initial CFA model.

	Definition	**Annotation**	**Reference**	**Values**
Exact Fit Index				
	Chi-Square, degrees of freedom, p-value	χ^2, ***df, p***	No significance	287.92 (24), .001
Approximate Fit Index				
Absolute Fit Index	Root Mean Square Error of Approximation (Lower, Upper Confidence Interval)	**RMSEA (L, U)**	.05 to .08	.13 (.117, .143)
Incremental Fit Index	Comparative Fit Index	**CFI**	≥.9	.925
Absolute Fit Index	Standardized Root Mean Square Residual	**SRMR**	≤.08	.0443
To Compare Models				
	Akaike Information Criterion	**AIC**	Smaller value	329.92
	Bayesian Information Criterion	**BIC**	Smaller value	424.07

Figure 4. Graphical representation of the final CFA model.



Abbreviations: E, Error term, P. Int, Pain Intensity, P. Unpl, Pain Unpleasantness, P. Interf, Pain Interference, P. Disab, Pain-related Disability.

Nomenclature: Circles indicate the three latent variables: psychological, fatigue, and pain outcomes. The rectangles are the indicator variables. Curve arrows indicate correlations between the latent variables or error terms. Straight lines represent direct effects.

Table 5. Standardized factor loadings of the final CFA model.

Latent Variables	**Observed Variables**	**Standardized Factor Loadings**	***P***	***R^2***
Psychological				
	Psychological Distress	.90	--	.81
	Affective Distress	.62	.001	.39
	Life Satisfaction	.56	.001	.30
	Life Control	.60	.001	.33
Fatigue				
	General Fatigue	.73	--	.53
	Mental Fatigue	.79	.001	.62
	Emotional Fatigue	.80	.001	.63
	Physical Fatigue	.70	.001	.48
Pain Outcomes				
	Pain Intensity Time 2	.84	.001	.70
	Pain Unpleasantness Time 2	.90	--	.82
	Pain Interference Time 2	.85	.001	.72
	Pain-related Disability Time 2	.95	.001	.90

Abbreviations: *P*, p-value, R^2, coefficient of determination.

Table 6. Global model fit indexes for the final CFA model.

	Definition	**Annotation**	**Reference**	**Values**
Exact Fit Index				
	Chi-Square, degrees of freedom, p-value	χ^2, ***df, p***	No significance	111.54 (47), .001
Approximate Fit Index				
Absolute Fit Index	Root Mean Square Error of Approximation (Lower, Upper Confidence Interval)	**RMSEA (L, U)**	.05 to .08	.07 (.053, .087)
Incremental Fit Index	Comparative Fit Index	**CFI**	≥.9	.971
Absolute Fit Index	Standardized Root Mean Square Residual	**SRMR**	≤.08	.0495
To Compare Models				
	Akaike Information Criterion	**AIC**	Smaller value	173.54
	Bayesian Information Criterion	**BIC**	Smaller value	286.21

Table 7. Measures of reliability for the final CFA model.

	CR	**AVE**	**MSV**	**1**	**2**	**3**
Psychological F (1)	0.8	0.5	0.9	**0.7**		
Fatigue F (2)	0.8	0.6	0.9	0.9	**0.8**	
Pain Outcome F (3)	0.9	0.8	0.1	0.4	0.3	**0.9**

Abbreviations: CR, composite reliability, AVE, Average Variance Estimator, MSV, Maximum Shared Variance, F, Factor.

Table 8. Pearson correlations for continuous variables of CFA/SEM model.

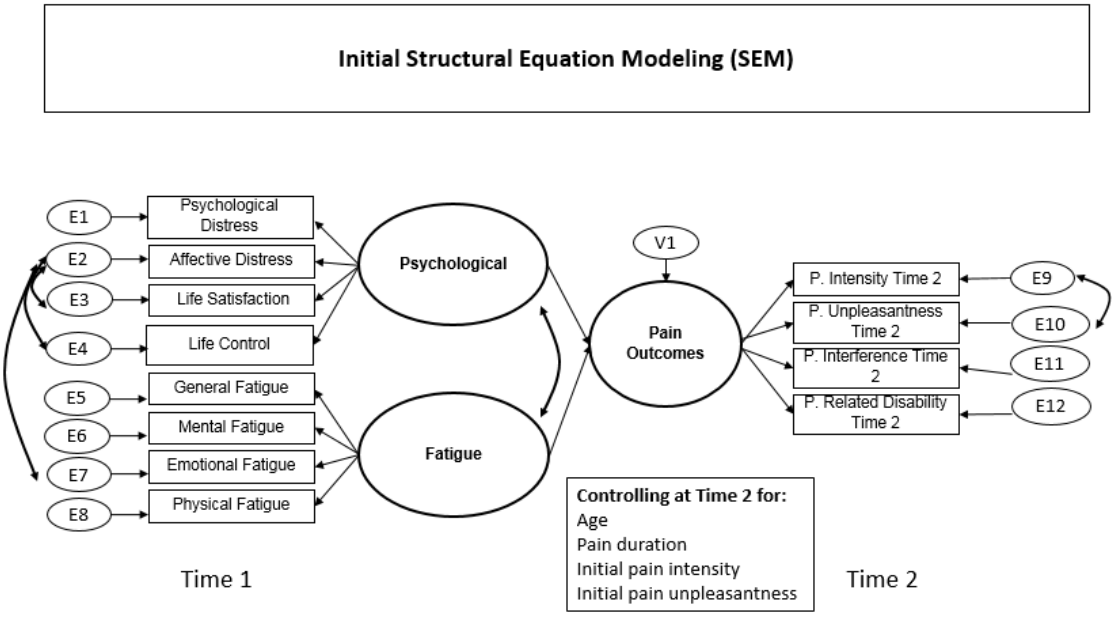
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1.Psy.Dis	1	.466**	.575**	.517**	.625**	.726**	.600**	.670**	.306**	.277**	.301**	.296**
2.SWL		1	.384**	.488**	.377**	.492**	.290**	.401**	.213**	.204**	.293**	.277**
3.Aff.Dis			1	.623**	.442**	.637**	.312**	.430**	.166**	.143*	.238**	.191**
4.Lif.Cntr				1	.436**	.532**	.303**	.424**	.108	.061	.157**	.092
5.Gen.F					1	.509**	.567**	.619**	.189**	.172**	.205**	.208**
6.Emot.F						1	.509**	.599**	.160**	.112	.194**	.172**
7.Phys.F							1	.593**	.276**	.286**	.286**	.282**
8.Ment.F								1	.156**	.209**	.247**	.231**
9.P. Int. T2									1	.846**	.701**	.795**
10.P. Unpl. T2										1	.766**	.856**
11.P. Interf. T2											1	.800**
12.P. Disab. T2												1

****. Correlation is significant at the .01 level (2-tailed).**

***. Correlation is significant at the .05 level (2-tailed).**

Abbreviations: Psy.Dis, Psychological Distress, SWL, Satisfaction with Life, Aff.Dis, Affective Distress, Lif.Contr, Life Control, Gen.F, General Fatigue, Emo.F, Emotional Fatigue, Phys.F, Physical Fatigue, Ment.F, Mental Fatigue, P. Int, Pain Intensity, P. Unpl, Pain Unpleasantness, P. Interf, Pain interference, P. Disab=, Pain-related Disability, T2, Time 2.

Figure 5. Graphical representation of the SEM model.



This model assumes correlations between all controlling variables as well as between controlling variables and psychological and fatigue factors.

Abbreviations: E, Error terms associated to observed variables, V1, Error term associated to latent variable, P, Pain

Nomenclature: Circles indicate the three latent variables: psychological, fatigue, and pain outcomes. The rectangles are the indicator variables. Curve arrows indicate correlations between the latent variables or error terms. Straight lines represent direct effects.

Table 9. Global model fit indexes for the SEM model.

	Definition	**Annotation**	**Reference**	**Values**
Exact Fit Index				
	Chi-Square, degrees of freedom, p-value	χ^2, ***df, p***	No significance	216.17 (83), .001
Approximate Fit Index				
Absolute Fit Index	Root Mean Square Error of Approximation (Lower, Upper Confidence Interval)	**RMSEA (L, U)**	.05 to .08	.076 (.064, .088)
Incremental Fit Index	Comparative Fit Index	**CFI**	≥.9	.947
Absolute Fit Index	Standardized Root Mean Square Residual	**SRMR**	≤.08	.0533
To Compare Models				
	Akaike Information Criterion	**AIC**	Smaller value	322.065
	Bayesian Information Criterion	**BIC**	Smaller value	510.71

Table 10. Maximum likelihood regression estimates for the SEM.

Parameter	**Unstd.**	**SE**	**Std.**	***P***
Psychological F → Pain Outcome F	1.178	1.045	.850	.260
Fatigue F → Pain Outcome F	-.783	.892	-.640	.380
P. Intensity T1 → Pain Outcome F	.003	.008	.029	.704
P. Unpleasantness T1 → Pain Outcome F	.002	.001	.181	**.004**
Age T1 → Pain Outcome F	-.003	.001	-.137	**.030**
P. Duration T1 → Pain Outcome F	.001	.0001	.216	**.004**

Abbreviations: Unstd, Unstandardized, SE, Standard error, Std, Standardized, *P*, p-value, F, Factor, P, Pain.

8. References

1. de Leeuw R, Klasser GD. Orofacial Pain: Guidelines for Assessment, Diagnosis, and Management. 5 th edition ed. Chicago: Quintessence; 2013. p. 127-152.
2. Merskey H, Bogduk N. Classification of chronic pain, IASP Task Force on Taxonomy. *IASP Press, Seattle* 1994.
3. Okeson JP. Bell's Orofacial Pains. The Nature of Pain. 7th ed. Hanover Park, IL: Quintessence Publishing Co, Inc.; 2014. p. 3-12.
4. Lipton JA, Ship JA, Larach-Robinson D. Estimated prevalence and distribution of reported orofacial pain in the United States. *J Amer Dental Assoc* 1993;124:115-121.
5. Burris JL, Evans DR, Carlson CR. Psychological correlates of medical comorbidities in patients with temporomandibular disorders. *J Amer Dental Assoc* 2010;141:22-31.
6. Granot M, Ferber SG. The roles of pain catastrophizing and anxiety in the prediction of postoperative pain intensity: a prospective study. *Clin J Pain* 2005;21:439-445.
7. Haythornthwaite JA, Sieber WJ, Kerns RD. Depression and the chronic pain experience. *Pain* 1991;46:177-184.
8. Keefe FJ, Wilkins RH, Cook Jr WA, et al. Depression, pain, and pain behavior. *J Consul Clin Psychol* 1986;54:665.
9. Spiegel D, Sands S, Koopman C. Pain and depression in patients with cancer. *Cancer* 1994;74:2570-2578.

10. Tang J, Gibson SJ. A psychophysical evaluation of the relationship between trait anxiety, pain perception, and induced state anxiety. *J Pain* 2005;6:612-619.

11. Ohrbach R, Dworkin SF. Five-year outcomes in TMD: relationship of changes in pain to changes in physical and psychological variables. *Pain* 1998;74:315-326.

12. Macfarlane T, Blinkhorn A, Davies R, et al. Predictors of outcome for orofacial pain in the general population: a four-year follow-up study. *J Dent Res* 2004;83:712-717.

13. Ozdemir-Karatas M, Peker K, Balik A, et al. Identifying potential predictors of pain-related disability in Turkish patients with chronic temporomandibular disorder pain. *J Headache Pain* 2013;14:17.

14. Auerbach SM, Laskin DM, Frantsve LME, et al. Depression, pain, exposure to stressful life events, and long-term outcomes in temporomandibular disorder patients. *J Oral Maxillofac Surg* 2001;59:628-633.

15. Carlson CR. Psychological considerations for chronic orofacial pain. *Oral Maxillofac Surg Clinic North Am* 2008;20:185.

16. Carlson CR, Reid KI, Curran SL, et al. Psychological and physiological parameters of masticatory muscle pain. *Pain* 1998;76:297-307.

17. Slade GD, Diatchenko L, Bhalang K, et al. Influence of psychological factors on risk of temporomandibular disorders. *J Dental Res* 2007;86:1120-1125.

18. Fillingim RB, Ohrbach R, Greenspan JD, et al. Potential psychosocial risk factors for chronic TMD: descriptive data and empirically identified domains from the OPPERA case-control study. *J Pain* 2011;12:T46-T60.

19. Bair MJ, Robinson RL, Katon W, et al. Depression and pain comorbidity: a literature review. *Arch Intern Med* 2003;163:2433-2445.

20. Carlson CR, Miller CS, Reid KI. Psychosocial profiles of patients with burning mouth syndrome. *J Orofac Pain* 2000;14:59-64.

21. Daniel HC, Narewska J, Serpell M, et al. Comparison of psychological and physical function in neuropathic pain and nociceptive pain: implications for cognitive behavioral pain management programs. *Eur J Pain* 2008;12:731-741.

22. Fishbain DA, Cutler R, Rosomoff HL, et al. Chronic pain-associated depression: antecedent or consequence of chronic pain? A review. *Clin J Pain* 1997;13:116-137.

23. Arnstein P, Caudill M, Mandle CL, et al. Self efficacy as a mediator of the relationship between pain intensity, disability and depression in chronic pain patients. *Pain* 1999;80:483-491.

24. Monteiro DR, Zuim PRJ, Pesqueira AA, et al. Relationship between anxiety and chronic orofacial pain of temporomandibular disorder in a group of university students. *J Prosthodont Res* 2011;55:154-158.

25. Giannakopoulos NN, Keller L, Rammelsberg P, et al. Anxiety and depression in patients with chronic temporomandibular pain and in controls. *J Dent* 2010;38:369-376.

26. Sherman JJ, Carlson CR, Wilson JF, et al. Post-traumatic stress disorder among patients with orofacial pain. *J Orofac Pain* 2005;19:309-317.

27. Bertoli E, de Leeuw R, Schmidt JE, et al. Prevalence and impact of post-traumatic stress disorder symptoms in patients with masticatory muscle or

temporomandibular joint pain: differences and similarities. *J Orofac Pain* 2007;21:107-119.

28. Burris JL, Cyders MA, de Leeuw R, et al. Posttraumatic stress disorder symptoms and chronic orofacial pain: an empirical examination of the mutual maintenance model. *J Orofac Pain* 2009;23:243-252.
29. de Leeuw R, Bertoli E, Schmidt JE, et al. Prevalence of post-traumatic stress disorder symptoms in orofacial pain patients. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;99:558-568.
30. de Leeuw R, Schmidt JE, Carlson CR. Traumatic stressors and post-traumatic stress disorder symptoms in headache patients. *Headache* 2005;45:1365-1374.
31. de Leeuw R, Studts JL, Carlson CR. Fatigue and fatigue-related symptoms in an orofacial pain population. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;99:168-174.
32. Nes LS, Carlson CR, Crofford LJ, et al. Individual differences and self-regulatory fatigue: optimism, conscientiousness, and self-consciousness. *Pers Individ Dif* 2011;50.
33. Eisenlohr-Moul TA, Burris JL, Evans DR. Pain acceptance, psychological functioning, and self-regulatory fatigue in temporomandibular disorder. *Health Psychol* 2013;32:1236.
34. Boggero IA, Kniffin TC, de Leeuw R, et al. Fatigue mediates the relationship between pain interference and distress in patients with persistent orofacial pain. *J Oral Facial Pain Headache* 2014;28:38-45.

35. Boggero IA, Rojas-Ramirez MV, Carlson CR. All Fatigue is Not Created Equal: The Association of Fatigue and Its Subtypes on Pain Interference in Orofacial Pain. *Clin J Pain* 2017;33:231-237.

36. Kline RB. Principles and practice of structural equation modeling. Fourth Ed ed. New York: The Guilford Press; 2016.

37. Derogatis LR, Rickels K, Rock AF. The SCL-90 and the MMPI: a step in the validation of a new self-report scale. *Brit J Psychiat* 1976;128:280-289.

38. Hardt J, Gerbershagen HU, Franke P. The symptom check- list, SCL- 90- R: its use and characteristics in chronic pain patients. *Eur J Pain* 2000;4:137-148.

39. Yap AU, Tan KB, Prosthodont C, et al. Depression and somatization in patients with temporomandibular disorders. *J Prosthet Dent* 2002;88:479-484.

40. Kerns RD, Turk DC, Rudy TE. The West Haven-Yale Multidimensional Pain Inventory (WHYMPI). *Pain* 1985;23:345-356.

41. Boggero IA, Carlson CR. Somatosensory and affective contributions to emotional, social, and daily functioning in chronic pain patients. *Pain Med* 2014.

42. Turk DC. Psychosocial and behavioral assessment of patients with temporomandibular disorders: diagnostic and treatment implications. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997;83:65-71.

43. Diener E, Emmons RA, Larsen RJ, et al. The Satisfaction With Life Scale. *J Pers Assess* 1985;49:71-75.

44. McGregor NR, Butt HL, Zerbes M, et al. Assessment of pain (distribution and onset), symptoms, SCL-90-R inventory responses, and the association with

infectious events in patients with chronic orofacial pain. *J Orofac Pain* 1996;10:339-350.

45. McNeil DW, Au AR, Zvolensky MJ, et al. Fear of pain in orofacial pain patients. *Pain* 2001;89:245-252.
46. Andreu Y, Galdon MJ, Durá E, et al. An examination of the psychometric structure of the Multidimensional Pain Inventory in temporomandibular disorder patients: a confirmatory factor analysis. *Head Face Med* 2006;2:48.
47. Stein KD, Martin SC, Hann DM, et al. A multidimensional measure of fatigue for use with cancer patients. *Cancer Pract* 1998;6:143-152.
48. Stein KD, Jacobsen PB, Blanchard CM, et al. Further validation of the multidimensional fatigue symptom inventory-short form. *J Pain Symptom Manage* 2004;27:14-23.
49. Lin J, Brimmer DJ, Maloney EM, et al. Further validation of the Multidimensional Fatigue Inventory in a US adult population sample. *Popul Health Metr* 2009;7:1-12.
50. Von Korff M, Ormel J, Keefe FJ, et al. Grading the severity of chronic pain. *Pain* 1992;50:133-149.
51. Tabachnick B, Fidell L. Multivariate analysis of variance and covariance; 2007.
52. Browne MW, Cudeck R. Alternative ways of assessing model fit; 1993.
53. Bentler PM. Comparative fit indexes in structural models. *Psychol. Bull* 1990;107:238.

54. Kenny D, Kashy D, Bolger N. Data analysis in social psychology (In D. Gilbert, S. Fiske, & G. Lindzey (Eds.). The handbook of social psychology (Vol. 1, pp. 233–265): Boston, MA: McGraw-Hill; 1998.

55. Dillman DA. Mail and telephone surveys: The total design method: Wiley New York; 1978.

56. Locker D, Grushka M. Response trends and nonresponse bias in a mail survey of oral and facial pain. *J Public Health Dent* 1988;48:20-25.

57. Thomson TL, Nemeth JM, Peng J, et al. Address- Based Sampling for Recruiting Rural Subpopulations: A 2- Phase, Multimode Approach. *J Rural Health*.

9. Acknowledgments

I would like to thank my professors at the Orofacial Pain Clinic for their continue support in my academic endeavors. I would also like to thank Dominique Zephyr, who guided me through the learning process of a new statistical method, and Dr. Philip Westgate for helping me with all the administrative management of the grant. Special thanks to my husband, Ian, for his endless support throughout this journey, he has always believed in me and has been there to encourage and support me when I most needed. Finally, I would like to thank my family, for allowing me to departure to a fascinating academic and life adventure and supporting me in every single step.

This study was supported by the American Academy of Orofacial Pain under their section for Research Funding. The content is solely the responsibility of the author and does not necessarily represent the official views of the American Academy of Orofacial Pain.

Approval by the Institutional Review Board of the University of Kentucky was granted (16-0643-P3K).

10. Biographical Sketch

Marcia Rojas graduated as a dentist from the University of Costa Rica and received a Master of Science degree in Orofacial Pain at the University of Kentucky. She recently finished a Master in Public Health and is a candidate for a Ph.D. in Epidemiology and Biostatistics. Additionally, she works as an Assistant Professor at the College of Dentistry and participates in distinct multidisciplinary research projects.

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