WORK DISTRACTION: EMPLOYER COSTS OF PREVENTABLE JOINT DISORDERS AND IMPLICATIONS FOR BUSINESS

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ABSTRACT

Presenteeism (or lost productivity due to work distraction) represents a major cost to businesses. One set of painful conditions that leads to presenteeism is temporomandibular joint disorders (TMDs), and this paper measures the per-person six-month cost of work distraction due to TMD symptoms. This study determined that per person over a six-month period, it costs employers an average of $2,649 for women and $2,342 for men for TMD-related work distraction. Findings reveal the effect of painful symptoms greatly outweighs the effect of non-painful symptoms in influencing work distraction. This study finds that the intervention of an effective novel method of treating TMD has important implications for businesses and employers through cost savings due to a reduction in painful TMD symptoms, with per-person savings of $1,775 for women and $1,748 for men. This paper contributes to the literature on pain and work by quantifying productivity costs for those with painful TMD symptoms.

Keywords*: Presenteeism, work distraction, the cost to employers, temporomandibular joint disorders, pain*

INTRODUCTION

Absenteeism and presenteeism are significant problems for businesses incurring high costs, ranging from 20.9 to 22.1% of total employer payroll costs (SHRM, 2014). Effects of illness-based absenteeism and presenteeism can be varied by the type of firm and the type of illness (i.e., acute or chronic) (Pauly et al., 2008), and firms are seeking ways to incorporate appropriate interventions to reduce illness-based absenteeism and presenteeism (Ammendolia et al., 2016).

As chronic conditions of the jaw joint, temporomandibular joint disorders (TMDs) are one set of illnesses causing absenteeism and presenteeism for firms in the United States. Those with a TMD could experience painful symptoms (such as headaches or jaw and neck pain) and non-painful symptoms (such as jaw locking or popping). Women are more likely to report having a TMD, with a U.K. estimate of 81% (Durham et al., 2016b), and an estimated 4.8 percent of adults in the United States (or 11.2 to 12.4 million people) reported pain around the TMJ in 2018 (NASEM, 2020).

Pain and chronic orofacial pain (COFP) as general categories have workplace impacts through absence and work distraction. Much less research exists on the impact of TMD pain or, even more specifically, TMD symptoms. The impact of pain on work is important as estimates put productivity costs for pain at $61.2 billion a year for common pain categories (Stewart et al., 2003) and about $1 billion a year (Canadian) for dental-related absenteeism (Hayes et al., 2013). A recent study puts the per-worker cost of persistent orofacial pain (POFP) at £1,575 ($2,059 in 2019 U.S. dollars) every six months (Breckons et al., 2018).

This study contributes to the literature on pain and work by creating estimates of work productivity loss specifically for individuals with TMDs, using measures of work distraction and American Community Survey income data. In this study, we answer three main research questions: (1) how are painful or non-painful TMD symptoms driving workplace distraction, (2) what is the cost of productivity (measured by workplace distraction) of having a TMD, and (3) what is the reduction in productivity cost due to TMD intervention? Though TMDs are generally included in studies dealing with work and orofacial pain (e.g., de Magalhães Barros et al., 2009; Lacerda, Traebert, and Zambenedetti, 2008), not all TMD symptoms are painful. This study uses novel survey data to measure how the severities of painful and non-painful TMD symptoms affect work distraction. To the authors' knowledge, this is the first study to measure the work distraction caused by TMDs specifically. Additionally, this study shows that intervention with the novel treatment for TMDs can reduce the lost productivity for employers.

The remainder of the paper presents the following: the literature surrounding the effect of chronic pain, orofacial pain, and dental pain on work; the data and the methodology in this study; and the results and conclusion.

LITERATURE REVIEW

Estimates of the effect of absenteeism and presenteeism can vary across research and by type (e.g., illness-based or family-based) (Shultz et al., 2009). Presenteeism is a more significant portion of the costs of illness than absenteeism (Pauly et al., 2008); therefore, employers and managers should be aware both of the costs of presenteeism for their firms and of the interventions available to reduce pain- and illness-based presenteeism (Ammendolia et al., 2016).

Research on pain and work primarily examines how the most common pain types (such as arthritis, back pain, and headache) affect work performance and absenteeism (Stewart et al., 2003). Stewart et al. (2003) estimate that working with painful conditions cost around $61.2 billion in 2003 (or $90.6 billion in 2021 dollars). Like this paper, prior research distinguishes between work absences due to pain and work distraction due to pain, also known as "presenteeism" (Stewart et al., 2008; Stewart et al., 2003). Other nationally representative studies similarly point to the necessity of measuring the costs of presenteeism for those with painful conditions (chronic pain: Barreto & Sá, 2019; Gaskin and Richard, 2012; van Leeuwen et al., 2006), as those with painful conditions are less likely to miss work and more likely to work while in pain.

Chronic or persistent orofacial pain (COFP or POFP) represents an umbrella term for four painful conditions: "temporomandibular disorder, atypical odontalgia, burning mouth syndrome, and atypical facial pain" (Peters et al., 2015, p. 778). COFP disorders are primarily studied together in terms of costs of treatments and costs to employers (Breckons et al., 2018).

Specific research on TMDs shows that the severity of an individual's TMD is positively correlated with her quality-of-life impact, and the effect on the quality of life for those with TMD pain is comparable to headaches and back pain in terms of affecting life and social costs (de Magalhães Barros et al., 2009). Additionally, individuals with TMDs use 10 to 20 percent more dental services than those without TMDs, accounting for an additional dental procedure a year (Hobson, Huang, and Covell, 2008). Though characterized by painful symptoms, temporomandibular disorders (TMDs) are also associated with mechanical jaw issues and other non-painful symptoms (such as trouble sleeping or earaches) (NASEM, 2020). This paper identifies the impact of painful versus non-painful TMD symptoms and measures the amount of lost productivity for those with TMDs.

A body of literature on orofacial and dental pain shows that pain of those types leads to work absences and presenteeism. Estimates for the effect of dental or orofacial pain on absenteeism range from nine to 27 percent (Lima and Buarque, 2019; Miotto et al., 2014; Lacerda, Traebert, and Zambenedetti, 2008), while estimates for work presenteeism range from 20 to 50 percent (Lima and Buarque, 2019; Miotto et al., 2014). Breckons et al. (2018) confirm using UK DEEP study survey data that the cost to employers of POFP of presenteeism is about four times as high as the cost of absenteeism. These studies reveal that while dental and orofacial health issues do impact employers through workers' absences, individuals with orofacial pain are less likely to miss work than they are to work while distracted by their pain. It is concluded that presenteeism, not absenteeism, makes up the majority of costs for employers of individuals with dental or orofacial pain. The distraction of pain leads to productivity losses and increases the chance of workplace injury (Lacerda, Traebert, and Zambenedetti, 2008).

This study follows the human capital method used in Breckons et al. (2018) to create the measures of indirect employer costs due to presenteeism. Breckons et al. also found that the intensity of POFP, measured by a dichotomized Graded Chronic Pain Scale, could predict both direct and indirect costs.

Table 1 presents the results of the literature dealing with the direct and indirect costs of painful conditions. The research in Table 1 points to the need to quantify productivity losses on an individual and national scale for specific types of painful conditions. While the studies in Table 1 provide point estimates for common painful conditions, dental-related conditions, and orofacial pain, our study focuses more narrowly on the effects of two types of TMD symptoms (painful and non-painful) on work distraction and productivity. Filling this gap in the literature on painful conditions and work is critical for advancing the knowledge in this area of research. To the authors' knowledge, this is the first study to quantify productivity losses due to TMDs. (See Najeddine et al. [2007] for correlates of work productivity losses for those with TMDs.) This study adds to the literature by determining the impacts on work distraction of painful and non-painful TMD symptoms and by providing estimates of the costs of work distraction for those with TMDs. Our results help inform firms' health and productivity management decisions (Shultz et al., 2009).

DATA

Survey

This study uses data attained through surveying a sample of TMD patients who had used a new medical device to relieve TMD symptoms (the Urbanek splint, hereafter U.S.). The Institutional Review Board (IRB) approved the survey of Middle Tennessee State University (request I.D. 21-10122q, approved 8/31/2020, expires 12/31/2021). Of the 844 potential respondents, 359 took the survey (response rate of 44%). After data cleaning and excluding those not employed and those with missing data, 128 (or 15%) remain for use in this study.

Table 1
SELECTED LITERATURE

Authors (Year)	Estimate of Lost Productivity Cost due to Pain	2019 USD[1,2]	Sample	Nationally-Representative	Condition	Other findings
Stewart et al. (2003)	$61.2 billion per year	$84.78 billion per year	American Productivity Audit, n = 28,902	Yes	Common pain conditions (e.g. headache, back pain, arthitis pain, musculoskeletal pain)	76.6% of cost is due to work distraction.
Gaskin and Richard (2012)	$299 to $334 billion in lost productivity	$332 to $371 billion in lost productivity	Medical Expenditure Panel Survey (2008), n = 15,945	Yes	Any type of pain	
Stewart et al. (2008)	1.8 hours a week per person of lost work time (lost productivity)		American Migraine Prevalence and Prevention Study, n = 5,997	Yes	Migraine	
Edmeads and Mackell (2002)	$710 per person per six months	$1,010 per person per six months	National Health and Wellness Study (1998), n = 1,087	Yes	Migraine	Two-thirds of costs of having migraines are due to lost productivity.
Hayes et al. (2013)	$1 billion (Canadian)	$807 million	Canadian Health Measures Survey (2007/2009), n = 5,586	Yes	Dental problems and treatment	
Barreto and Sa (2019)	$6.2 million per year		Brazilian sample of education workers, n = 54	No	Chronic pain	
van Leeuwen et al. (2006)	$5.1 billion (Austrailian)	$4.8 billion	New South Wales Health Survey (1997), n = 17,543 Northern Sydney Area Pain Study, n = 2,092	Yes	Chronic pain	
Breckons et al. (2018)	£1,575 per person per six months	$2059 per person per six months	U.K. Sample, (n = 198)	No	Persistent Orofacial Pain (POFP)	78.9% of cost is due to indirect costs (quality of work) and intensity of pain leads to greater indirect costs.

Note: Author's review of selected literature on pain and lost productivity.
[1]Calculations using BLS CPI Inflation Calculator https://data.bls.gov/cgi-bin/cpicalc.pl?cost1=334&year1=201201&year2=201901
[2]Canadian, Australian, and United Kingdom inflation calculations: https://www.in2013dollars.com/canada/inflation/2013?endYear=2019&amount=1 and https://www.exchangerates.org.uk/

Work Productivity Losses Costs due to Pain

The survey's focus was on the effect of the new medical device, the costs of previous treatments, the reported ease of use, and the reported patient satisfaction with the device. In order to measure the effectiveness of the device, the study used a before-and-after framework, where patients were asked to rate the severity of a list of 19 TMD symptoms in the six months prior to treatment with the device and after using the device. The averages for the painful and non-painful symptoms were taken separately for the two measures of symptom severity. Respondents were also asked to rate their level of work distraction in the six months prior to treatment with the device on a scale from 0 to 5, where 0 indicates no distraction and 5 indicates severe distraction. The measures of symptom severity and work distraction prior to treatment were used, along with demographic information collected in the survey, to measure the effect of painful and non-painful TMD symptom severity on work distraction. Then, work distraction measures (both before and after) were used to quantify the cost to employers for work distraction for individuals with TMDs.

Table 2 shows that the percentage of women in the data is consistent with the gender composition of those with a TMD found by Durham et al. (2016b). It is also acknowledged that those in the sample may have more severe TMD symptoms than others with TMDs, as the severity of their TMD had prompted them to search to find an orofacial surgery specialist. However, this is tempered by the fact that a continuing search for TMD symptom relief has been common in other studies (Seo et al., 2020).

Descriptive Statistics

Table 2 presents the descriptive statistics for the data used in this study. The individuals in the sample had moderate levels of work distraction (an average of 2.13 on a scale from 0 to 4 and 2.15 on a scale from 0 to 5), consistent with findings for those with common pain conditions (Stewart et al., 2003), dental pain (Lima & Buarque, 2019), chronic headache pain (Stewart et al., 2010), and COFP (Breckons et al., 2018). This confirms that those in the sample are not outliers in terms of work presenteeism. The range of ages in the sample is large (from 20 to 73), and the average age is 44. The average number of medical, dental, or other practitioners from which the individuals in the sample sought treatment (both before and after TMD diagnosis) is about three. The maximum number of practitioners reported in this sample is 15, which is in line with Breckons et al. (2018), who report that those with COFP had seen nine practitioners in the past six months alone. The average length of treatment for TMD symptoms (both before and after diagnosis) is about four years. Furthermore, the average number of TMD treatments to relieve TMD symptoms (before or after TMD diagnosis) for those surveyed is about 1.5.

Length of time with TMD diagnosis and length of time with TMD symptoms measures were recoded from range categories to years using the midpoint (e.g., “1 to 3 years” was recoded to 2 years). For the category “20 years or more,” the lower bound of 20 years was used. (See Table A4 in the Appendix for a complete list of range categories, the midpoints used, and the distribution of the sample among them.) The average length of time that an individual in the sample has had a TMD diagnosis is about seven and a half years. The average length of time an individual has had TMD symptoms before diagnosis is about eight years.

Raw work distraction (WD) data was collected on a scale from 0 to 5, where 0 is no work distraction, and 5 is complete work distraction before treatment with the U.S. For the sake of this paper, categories 4 and 5 of WD have been merged due to low reporting of category 5 (n = 2). The measure of high work distraction (HWD) contains the highest WD category: WD = 4. The measure of any work distraction (AWD) contains all WD categories that are greater than zero.

Table 2
DESCRIPTIVE STATISTICS

Gender	Women	79.41%		
	Men	20.59%		
	Average	St. Dev	Min	Max
Age	44.31	12.90	20.00	73.00
Practictioners	3.04	2.41	0.00	15.00
Length of Treatment for TMD symptoms	4.16	6.51	0.00	30.00
Number of TMD Treatments	1.48	1.44	0.00	5.00
Number of Comorbidities	3.48	2.52	0.00	10.00
Length of TMD Diagnosis	7.51	6.74	0.50	20.00
Length of TMD Symptoms Pre-Diagnosis	7.93	6.79	0.50	20.00
Raw Work Distraction (WD) Data	2.15	1.39	0.00	5.00
Work Distraction (WD)	2.13	1.36	0.00	4.00
WD = 0	19.53%			
WD = 1	11.72%			
WD = 2	20.31%			
WD = 3	32.81%			
WD = 4	15.63%			
High WD	15.63%			
Any WD	80.47%			
Work Distraction After Treatment (WDA)	0.70	1.04	0.00	4.00
Painful Symptom Severity	2.97	1.05	0.00	4.89
Non-Painful Symptom Severity	2.60	1.00	0.60	4.83
Painful Symptom Count	7.71	1.92	0.00	9.00
Non-Painful Symptom Count	7.75	2.48	1.00	10.00
Painful Symptoms / Total Symptoms	0.50	0.09	0.00	0.80

	Average Severity	Count	Percent of Total
Painful TMD Symptoms			
Jaw pain or jaw tension	3.85	127	96.95%
Neck and shoulder pain or tension	3.44	121	92.37%
Headache	3.31	120	91.60%
Pain with chewing	3.12	114	87.02%
Headache, jaw, or neck pain while sitting	3.27	111	84.73%
Ear pain	2.62	110	83.97%
Waking at night due to headache, jaw, or neck pain	2.88	104	79.39%
Shoulder pain	2.44	99	75.57%
Upper arm pain	1.65	81	61.83%
Non-Painful TMD Symptoms			
Clenching or grinding of teeth	3.93	123	93.89%
Jaw popping	3.23	120	91.60%
Limited mouth opening	2.99	114	87.02%
Ear ringing/tinnitus	2.71	109	83.21%
Jaw locking	2.49	100	76.34%
Dizziness	1.99	91	69.47%
Arm/hand/finger tingling or numbness	1.99	88	67.18%
Subjective hearing loss/fullness	1.91	86	65.65%
Vertigo	1.57	84	64.12%
Visual disturbances	1.21	77	58.78%

Source: Author’s Calculations
Note: “Percent of Total” refers to those in the sample with the symptom.

METHODOLOGY

Effect on Work Distraction: Painful versus Non-painful Symptoms

This study uses OLS and logit models to measure the severity of painful and non-painful TMD symptoms on work distraction (WD). The general formula for the ordinary least squares (OLS) models is presented below:

$$y_i = \alpha + \beta_1 PAIN_i + \beta_2 NPAIN_i + \sum_j \beta_j X_i + \epsilon_i, \tag{1}$$

where the subscript i represents the individual, PAIN represents the effects of an individual's painful TMD symptoms, and NPAIN represents the effects of an individual's non-painful TMD symptoms for either the severity or the count variables. X_i is a vector of demographic variables for each person that include age, gender, number of comorbidities, number of practitioners seen, length of time with TMD symptoms, length of time with TMD diagnosis, number of previous TMD treatments, and length of TMD symptom treatment. It should be noted that socioeconomic variables present in other studies (Miller et al., 2019) are not included in the model because those questions were not present in the original survey.

Our four variables of interest are the severity of painful symptoms, the severity of non-painful symptoms, the number of painful symptoms, and the number of non-painful symptoms. Due to strong correlations, the effects of severity measures and count measures cannot be determined in the same model. The primary model involves symptom severity, and robustness checks are conducted using the count variables for both the OLS models and the ordered logit models outlined in the next paragraph.

Our next set of models uses a proportional odds ordered logit regression function, as shown below:

$$P(y_i > j) = \frac{\exp(\alpha_j + X_i\beta_j)}{1 + \exp(\alpha_j + X_i\beta_j)}, j = 0, \dots, J-1, i = 1, \dots, n \tag{2}$$

where y_i is the category of work distraction for person i, j is the reference work distraction category, the subscript i represents the individual, and J is the number of work distraction categories. One difference between the two models is the intercept, where the ordered logit model intercepts are calculated separately for the distinct categories. The independent variables (including variables of interest and the vector of demographic variables) are the same in the ordered logit models as in the OLS model. The dependent variables for the ordered logit models are high work distraction (HWD) and any work distraction (AWD). For HWD, the ordered logit reference category is WD = 4, meaning the model measures what influences an individual to report category 4 of work distraction in the six months prior to treatment versus categories 0-3. For AWD, the reference category is WD = 0, meaning the model measures what influences an individual to report category 0 versus categories 1-4. The ordered logit uses separate intercepts for each category to calculate the odds ratio that the dependent variable is greater than the category of interest.

Costs of Work Distraction

To find the cost of work distraction for the sample and estimates for other U.S. cities, the human capital method (Hayes et al., 2013; van den Hout, 2010) is used, which values work distraction using individuals' income. The human capital approach assumes that an individual's income represents their contribution to an employer; thus, the value of the distracted hours represents the value of lost productivity. The formula used by Breckons et al. (2018) is as follows:

$$Productivity\ loss\ (hrs) = \left(1 - \frac{WD}{5}\right) \times H\ , \quad (3)$$

where WD is the rating of work distraction from 0 to 5, where 5 is no work distraction due to TMD symptoms and 0 is complete work distraction due to TMD symptoms. Full data (keeping category 5 of WD) is used in calculations of productivity losses. H represents the average number of hours in a typical workday. The productivity loss, thus, represents the number of hours in an affected day that are "lost" due to work distraction due to TMD symptoms for an individual per day. The productivity loss formula was revised to fit the data as shown below:

$$Productivity\ loss\ (hrs) = \frac{WD}{5} \times H\ . \quad (3.1)$$

To find the wages lost from the loss of productive hours, the productivity loss is multiplied by the average hourly wage (AHW), as shown below:

$$Productivity\ cost\ (\$) = Productivity\ loss\ (hrs) \times AHW. \quad (4)$$

The data collected by the survey has no measures of typical hours worked or average wages. However, this study imputes these measures using Integrated Public Use Microdata Survey (IPUMS) data from 2019. As the year falls between Census years, the sample of IPUMS data used is from the American Community Survey (ACS) 1% sample. Hayes et al. (2013) use occupation codes to match the average wages of individuals in their study. This study matches the average wages of individuals in the sample by these identifying factors: area (e.g., Atlanta, GA), age, full-time status, and gender. The same methodology is followed (matching by age, full-time status, and gender) to find the income estimates for the selected cities.

Income in ACS is reported by year, so the yearly income is divided by 48 to represent weekly income. The usual hours of work in a week variable reported in ACS were used to create a variable representing hourly wage. The usual hours of work a week variable were divided by five to get the usual hours of work per day. All these measures are the averages by age, full-time status, and gender. Full-time status is considered 40 hours or more a week. These calculated variables are reported in the Appendix.

The data has no measure of the number of days an individual worked with pain, so the estimate found by Breckons et al. (2018) is used for those with COFP of 34.6 days in a six-month period (or about 30% of workdays).

The measures of per person average cost per six months of work distraction (using the methods outlined above) was used to find the point estimates for the potential cost to employers due to TMD-related work distraction. Using non-seasonally-adjusted Bureau of Labor Statistics data for the sample MSAs in this paper, the number of those employed in an MSA is multiplied by the estimated percent of those in the United States reporting pain around the TMJ (4.8%, NASEM 2020). It is assumed that women make up 50% of those employed in an MSA. BLS estimates of national full-time work proportions for women and men for 2019 (74.9% and 86.2%, respectively, Bureau of Labor Statistics 2020) are used, and multiply 4.8% by the likelihood that someone with a TMD will be a woman (81%) (Durham et al., 2016b) to measure the costs separately for women and men.

RESULTS

Contributions of Painful and Non-painful Symptoms to Work Distraction

Table 3 reports the results for the OLS model measuring the effects that the severities of painful and non-painful symptoms have on work distraction (WD). The first model shows that painful symptom severity is positively related to WD. Using the sample average WD of 2.13 implies that a one-unit increase in the average severity of painful symptoms increases WD by about 38%. In the first model, non-painful symptoms are negatively related to work distraction. The coefficient implies a 12% decrease in WD for every one-unit increase in the average severity of non-painful symptoms. Both results are significant at the five percent level.

Table 3
WORK DISTRACTION (WD) OLS MODEL RESULTS
Symptom Severity

	(1)			(2)		
		95% CI			95% CI	
	Coefficient	Lower	Upper	Coefficient	Lower	Upper
Average of Painful Symptoms (0-5)	0.8124 *** *0.1126*	0.6186	1.0062	0.7620 *** *0.1326*	0.4914	1.0325
Average of Non-Painful Symptoms (0-5)	-0.2630 * *0.1195*	-0.5492	0.0231	-0.2514 . *0.1273*	-0.5689	0.0661
Gender				-0.5096 *0.3119*	-1.1783	0.1591
Age (years)				-0.0105 *0.0085*	-0.0300	0.0090
Length of diagnosis with TMD (years)				0.0176 *0.0176*	-0.0213	0.0566
Length of TMD symptoms before treatment (years)				0.0093 *0.0165*	-0.0250	0.0436
Number of practictioners				0.0453 *0.0507*	-0.0631	0.1538
Number of previous TMD Treatments				-0.0202 *0.0909*	-0.1666	0.1262
Total cost of TMD symptom treatment ($100s US dollars)				0.0006 *0.0007*	-0.0006	0.0019
Number of comorbidities				0.0321 *0.0495*	-0.0622	0.1264

Source: Author's Calculations
Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Table 4
HIGH WORK DISTRACTION (HWD) ORDERED LOGIT MODEL RESULTS
Symptom Severity

	(1)					(2)					(3)				
				95% CI					95% CI					95% CI	
	Coefficient		OR	Lower	Upper	Coefficient		OR	Lower	Upper	Coefficient		OR	Lower	Upper
Average of Painful Symptoms (0-5)	-1.2435 *0.2142*	***	**0.2884**	0.1863	0.4325	-1.2370 *0.2430*	***	**0.2903**	0.1774	0.4610	-1.0129 *0.1968*	***	**0.3632**	0.2443	0.5294
Average of Non-Painful Symptoms (0-5)	0.3989 *0.2030*	*	**1.4902**	1.0042	2.2310	0.4488 *0.2192*	*	**1.5665**	1.0232	2.4232					
Gender						0.7459 *0.5227*		**2.1084**	0.7592	5.9391	0.8895 *0.5100*	.	**2.4339**	0.8990	6.6914
Age (years)						0.0230 *0.0145*		**1.0232**	0.9947	1.0532	0.0244 *0.0142*	.	**1.0247**	0.9969	1.0540
Length of diagnosis with TMD (years)						-0.0303 *0.0290*		**0.9701**	0.9163	1.0268	-0.0212 *0.0280*		**0.9790**	0.9266	1.0344
Length of TMD symptoms before treatment (years)						-0.0161 *0.0271*		**0.9840**	0.9330	1.0378	-0.0266 *0.0253*		**0.9738**	0.9263	1.0232
Number of practitioners						-0.0864 *0.0854*		**0.9172**	0.7714	1.0849					
Number of previous TMD Treatments						0.0766 *0.1439*		**1.0796**	0.8151	1.4353	-0.0714 *0.1310*		**0.9311**	0.7202	1.2056
Total cost of TMD symptom treatment ($100s US dollars)						-0.0016 *0.0013*		**0.9984**	0.9952	1.0008					
Number of comorbidities						-0.0405 *0.0794*		**0.9603**	0.8212	1.1222	-0.0486 *0.0784*		**0.9525**	0.8160	1.1108

Source: Author's Calculations
Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1" 1. OR is Odds Ratio.

Table 5
ANY WORK DISTRACTION (AWD) ORDERED LOGIT MODEL RESULTS
Symptom Severity

	(1)					(2)					(3)				
				95% CI					95% CI					95% CI	
	Coefficient		OR	Lower	Upper	Coefficient		OR	Lower	Upper	Coefficient		OR	Lower	Upper
Average of Painful Symptoms (0-5)	1.2435 *0.2142*	***	**3.4679**	2.3121	5.3687	1.2370 *0.2430*	***	**3.4453**	2.1692	5.6381	1.0129 *0.1968*	***	**2.7535**	1.8888	4.0939
Average of Non-Painful Symptoms (0-5)	-0.3989 *0.2030*	*	**0.6710**	0.4482	0.9958	-0.4489 *0.2192*	*	**0.6384**	0.4127	0.9773					
Gender						-0.7460 *0.5227*		**0.4743**	0.1684	1.3171	-0.8895 *0.5100*	.	**0.4109**	0.1494	1.1124
Age (years)						-0.0230 *0.0145*		**0.9773**	0.9495	1.0054	-0.0244 *0.0142*	.	**0.9759**	0.9488	1.0032
Length of diagnosis with TMD (years)						0.0303 *0.0290*		**1.0308**	0.9739	1.0914	0.0212 *0.0280*		**1.0215**	0.9668	1.0792
Length of TMD symptoms before treatment (years)						0.0161 *0.0271*		**1.0162**	0.9635	1.0718	0.0266 *0.0253*		**1.0270**	0.9773	1.0795
Number of practitioners						0.0864 *0.0854*	***	**1.0903**	0.9218	1.2963					
Number of previous TMD Treatments						-0.0766 *0.1439*		**0.9263**	0.6967	1.2268	0.0714 *0.1310*		**1.0740**	0.8294	1.3884
Total cost of TMD symptom treatment ($100s US dollars)						0.0016 *0.0013*		**1.0016**	0.9992	1.0048					
Number of comorbidities						0.0405 *0.0794*		**1.0413**	0.8911	1.2177	0.0486 *0.0784*		**1.0498**	0.9002	1.2255

Source: Author's Calculations
Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1" 1. OR is Odds Ratio.

The second model of Table 3 reinforces the findings of the first model, with the magnitude of the effect of painful symptom severity decreasing slightly. The implied percentage change of WD is about 36% and -12% for painful and non-painful symptom severity, respectively. The controlling variables' coefficients in the second model are smaller in magnitude than the two variables of interest and not significant, meaning that work distraction is not affected by the controlling variables.

Tables 4 and 5 report the ordered logit model results for the effects of painful and non-painful symptoms on the likelihood of high work distraction (HWD) and any work distraction (AWD), respectively. The results of interest are the odds ratios (OR) in bold. The coefficients for Tables 4 and 5 are the same but show opposite signs, meaning that the ordered logit model specifications are the same but the direction of interest (i.e., higher versus lower) and thus the OR calculations differ. Each table has three model specifications, the first showing only the effects of painful and non-painful symptoms, the second showing the full model effects, and the third showing only variables passing the parallel regression assumption of ordered logit models (Brant test in R).

Additionally, in all ordered logit models (including the count models in Tables 7 and 8), the WD categories are 0-4, where 0 is no WD and 4 is the highest WD. In the data, the WD categories are 0-5, and we collapsed categories 4 and 5 together in the main results due to a low reporting of category 5 (n=2 for category 5). We ran robustness tests where we dropped category 5 altogether and the results show no substantial differences from reported results.

Table 4 reports the ordered logit results for the effects of painful and non-painful symptom severities on the likelihood of high work distraction (HWD). In Model 1 of Table 4, a one-unit increase in the average intensity of painful symptoms decreases the likelihood that individuals in this model will have lower levels of work distraction by about 71%. This means that as painful symptom intensity increases, individuals are 71% more likely to report the highest level of work distraction. For a one-unit increase in non-painful symptoms, individuals are about 50% more likely to have lower levels of work distraction. This effect is counterintuitive, though significant at the 5% level. The counterintuitive findings of non-painful symptoms stem from how a non-painful symptom is reported by an individual, and we elaborate more on this finding later in this section.

In Model 2 of Table 4, we show that all control variable effects hover around 1, which is interpreted as no effect. The one exception is gender, where women are two times as likely to report lower levels of work distraction than men. No control variables show significance at the 10% level in Model 2. In Model 3 of Table 4, a one-unit increase in painful symptoms is related to a 64% increase in an individual reporting HWD, meaning individuals with more intense painful symptoms are more likely to report HWD. Gender in our model is a binary variable where Woman = 1 and Man = 0. Women in our sample are about 2.5 times less likely to report HWD than men in our sample (significant at the 10% level). In Model 3, age becomes a significant explanatory variable for HWD (significant at the 10% level). An increase of 10 years in age implies a 25% decrease in the likelihood of reporting HWD. This can be explained by older workers with a long history of HWD leaving the labor force and thus our sample, or it can be explained by older workers becoming used to working with severe TMD symptoms and underreporting their level of WD.

In order to investigate the effect of non-painful symptom intensity on work distraction, we separately regressed the intensity of the 10 non-painful symptoms to see if any of them drove the significant results presented above. Though most of the individual non-painful symptoms passed the parallel assumption, none of the effects were significant. We can conclude that non-painful symptom intensity is not a driving factor of work distraction. One reason for this might be that non-painful symptom intensity cannot be measured in the same way as painful symptom intensity. E.g., how does an individual define intensity as it relates to jaw locking? A better measure of intensity of non-painful symptoms might be by counting instances of experiencing the symptom in the past week. Future research should consider this when measuring the intensity of non-painful TMD symptoms.

Table 5 reports the ordered logit results for the effects of painful and non-painful symptom severities on the likelihood of any work distraction (AWD). Unsurprisingly, AWD is positively affected by painful symptom severity. In Model 1, a one-unit increase in the average intensity of painful symptoms increases the likelihood that individuals in this model will have work distraction by 347% (or are about three and a half times more likely to have work distraction that is not zero). However, a one-unit increase in the average intensity of non-painful symptoms decreases the likelihood that individuals will have work distraction by about 33% (0.67 – 1 x 100). This is counterintuitive to prior beliefs about the non-painful symptom's effect on work distraction. While this effect is significant at the 5% level, the parallel regression assumption for this variable does not hold.

In Model 2 of Table 5, we show all control variables except gender have no effect on the likelihood of having work distraction. In this case, no effect is characterized by an odds ratio near 1. Model 2 also shows that the number of practitioners seems to be a significant variable but does not pass the parallel regression assumption. Model 3 results imply that only the severity of painful symptoms, gender, and age have significant and large effects on an individual experiencing AWD. A one-unit increase in the severity of painful symptoms implies that an individual is nearly three times (275%) more likely to experience any work distraction. When gender increases by one unit (i.e., the individual is a woman), the likelihood that the individual will experience AWD decreases by 59%. This is driven by the low representation of men in our sample (only 20%) and that the men in our sample have a lower frequency of experiencing no work distraction relative to the women in our sample. For a 10-year increase in age, the likelihood of experiencing AWD decreases by 24%, and the reasons are likely those presented above in the results for HWD (e.g., older worker leaving work force).

Robustness: Using Painful and Non-painful Symptom Count Variables

As a robustness check on the symptom severity results, the models above were run with the painful and non-painful symptom count variables. Both count and severity variables measure the intensity of the painful or non-painful symptoms. As outlined in the descriptive statistics, individuals experience an average of about 7.71 painful symptoms and 7.75 non-painful symptoms. Table 6 presents the OLS results of the count model for WD. An additional painful symptom increases WD by 13% (using the sample mean of 2.13 for WD) in the first model and

14% in the second model. Both models' painful symptom count coefficients are significant at the 1% level.

Table 6
WORK DISTRACTION (WD) OLS MODEL RESULTS
Symptom Count

	(1)			(2)		
		95% CI			95% CI	
	Coefficient	Lower	Upper	Coefficient	Lower	Upper
Count of Painful Symptoms	0.2777 ** *0.0827*	0.1239	0.4315	0.3008 *** *0.0838*	0.1657	0.4358
Count of Non-Painful Symptoms	0.0322 *0.0645*	-0.0979	0.1623	-0.0491 *0.0684*	-0.1951	0.0969
Gender				-0.1376 *0.3280*	-0.7422	0.4670
Age (years)				-0.0088 *0.0091*	-0.0288	0.0111
Length of diagnosis with TMD (years)				0.0147 *0.0184*	-0.0150	0.0444
Length of TMD symptoms before treatment (years)				0.0208 *0.0176*	-0.0051	0.0467
Number of practictioners				0.0712 *0.0530*	-0.0484	0.1908
Number of previous TMD Treatments				0.0440 *0.0921*	-0.0902	0.1783
Total cost of TMD symptom treatment ($100s US dollars)				0.0007 *0.0007*	-0.0012	0.0027
Number of comorbidities				0.0673 *0.0519*	-0.0413	0.1758

Source: Author's Calculations
Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Table 7
HIGH WORK DISTRACTION (HWD) ORDERED LOGIT MODEL RESULTS
Symptom Count

	(1)				(2)				(3)			
			95% CI				95% CI				95% CI	
	Coefficient	OR	Lower	Upper	Coefficient	OR	Lower	Upper	Coefficient	OR	Lower	Upper
Average Count of Painful Symptoms	-0.4194 *** *0.1340*	**0.6574**	0.5000	0.8484	-0.4825 *** *0.1434*	**0.6172**	0.4610	0.8109	-0.4836 *** *0.1423*	**0.6166**	0.4615	0.8085
Average Count of Non-Painful Symptoms	-0.0403 *0.0967*	**0.9605**	0.7934	1.1607	0.0681 *0.1065*	**1.0705**	0.8679	1.3200	0.0611 *0.1054*	**1.0630**	0.8636	1.3078
Gender					-0.0057 *0.5064*	**0.9943**	0.3654	2.6838	0.0347 *0.5018*	**1.0353**	0.3840	2.7702
Age (years)					0.0158 *0.0145*	**1.0160**	0.9874	1.0454	0.0192 *0.0141*	**1.0194**	0.9915	1.0482
Length of diagnosis with TMD (years)					-0.0210 *0.0278*	**0.9792**	0.9271	1.0342	-0.0228 *0.0276*	**0.9774**	0.9257	1.0319
Length of TMD symptoms before treatment (years)					-0.0328 *0.0265*	**0.9677**	0.9184	1.0193	-0.0449 . *0.0250*	**0.9561**	0.9098	1.0039
Number of practicioners					-0.1400 *0.0882*	**0.8693**	0.7262	1.0301				
Number of previous TMD Treatments					-0.0375 *0.1342*	**0.9632**	0.7402	1.2550	-0.1252 *0.1278*	**0.8823**	0.6862	1.1341
Total cost of TMD symptom treatment ($100s US dollars)					-0.0016 *0.0013*	**0.9984**	0.9952	1.0009				
Number of comorbidities					-0.0886 *0.0776*	**0.9152**	0.7851	1.0655	-0.1251 *0.0763*	**0.8824**	0.7588	1.0246

Source: Author's Calculations
Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. OR is Odds Ratio.

Table 8
Any Work Distraction (AWD) Ordered Logit Model Results
Symptom Count

	(1)					(2)					(3)				
				95% CI					95% CI					95% CI	
	Coefficient		OR	Lower	Upper	Coefficient		OR	Lower	Upper	Coefficient		OR	Lower	Upper
Average Count of Painful Symptoms	0.4195 *0.1340*	***	**1.5211**	1.1788	2.0001	0.4825 *0.1434*	***	**1.6202**	1.2332	2.1691	0.4836 *0.1423*	***	**1.6219**	1.2369	2.1669
Average Count of Non-Painful Symptoms	0.0403 *0.0967*		**1.0411**	0.8615	1.2604	-0.0681 *0.1065*		**0.9342**	0.7576	1.1522	-0.0611 *0.1054*		**0.9408**	0.7647	1.1579
Gender						0.0058 *0.5064*		**1.0058**	0.3726	2.7367	-0.0346 *0.5018*		**0.9659**	0.3610	2.6044
Age (years)						-0.0158 *0.0145*		**0.9843**	0.9565	1.0128	-0.0192 *0.0141*		**0.9810**	0.9540	1.0086
Length of diagnosis with TMD (years)						0.0210 *0.0278*		**1.0212**	0.9670	1.0787	0.0228 *0.0276*		**1.0231**	0.9691	1.0802
Length of TMD symptoms before treatment (years)						0.0328 *0.0265*		**1.0333**	0.9810	1.0888	0.0449 *0.0250*	.	**1.0460**	0.9961	1.0991
Number of practictioners						0.1400 *0.0882*		**1.1503**	0.9708	1.3771					
Number of previous TMD Treatments						0.0375 *0.1342*		**1.0382**	0.7968	1.3510	0.1252 *0.1278*		**1.1334**	0.8817	1.4574
Total cost of TMD symptom treatment ($100s US dollars)						0.0016 *0.0013*		**1.0016**	0.9991	1.0048					
Number of comorbidities						0.0886 *0.0776*		**1.0927**	0.9386	1.2737	0.1251 *0.0763*		**1.1333**	0.9760	1.3178

Source: Author's Calculations
Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. OR is Odds Ratio.

Tables 7 and 8 report the results for HWD and AWD using the symptom count variables. These models generally support the findings of the severity models, with increases in painful symptom counts increasing the probability of HWD and AWD and non-painful symptoms decreasing the probability of HWD and AWD. For the HWD model, an additional painful symptom increases the probability of HWD by about 38% in the final model (Model 3). An additional non-painful symptom decreases the probability of HWD by about 6% in the final model. For the AWD model, an additional painful symptom increases the probability of AWD by about 62% in the final model, while an additional non-painful symptom is associated with a 6% decrease in AWD. In the symptom count models, we investigate if the number of TMD symptoms influences work distraction. As the count models show, the count of non-painful symptoms is not a better predictor of work distraction, underscoring the need for a better measure of non-painful symptom intensity.

To test the sensitivity of collapsing categories 4 and 5 of WD into one category, we also conducted tests where we removed category 5 and tested the effects of the type of symptom on HWD and AWD using categories 0-4 only. Results remained robust, both in magnitude and significance.

The models suggest, and the robustness tests confirm that painful symptoms are a larger part of work distraction than non-painful symptoms, even as the individuals in the sample have about the same number of painful versus non-painful TMD symptoms prior to treatment with the Urbanek Splint (U.S.).

Costs of Work Distraction to Employers

Table 9 reports the per-person costs of work distraction for those in the sample based on imputed hourly wages and weekly hours worked matched to our sample using location, age, and gender. Imputed hourly wages and weekly hours are presented in the appendix. Table 9 also reports the 95% confidence interval of costs of work distraction. The per-person average cost of work distraction for six months (using the estimate of 34.6 workdays with painful symptoms in a six-month period) ranges from $2,055 to $3,245 for women in the sample MSA and ranges from $1,963 to $2,721 for men. Using the mean six-month cost of work distraction, the total six-month cost to employers of work distraction for the sample is $286,118 for women and $46,837 for men.

The costs for the selected cities across the United States are also reported by using the same methodology and the work distraction measures for the sample.

Table 10 shows the calculations of the total MSA-level costs of work distraction and savings after treatment, using the work distraction measures in the sample and imputed values from Table 9 and the post-intervention level of work distraction. For the per-person savings due to use of the U.S. and subsequent decrease in work distraction, the average reduction in work distraction after treatment is about 68% for women and 74% for men. For a six-month period, the per-person savings due to reduced work distraction after treatment ranges from $1,347 to $2,205 for women and $1,464 to $2,031 for men. The total six-month savings for employers using the mean per-person savings is $191,740 for women and $34,953 for men.

For the MSA-level costs of work distraction and savings after treatment, since the age distribution from the sample is used, the city estimates for costs and savings at the MSA level are only for comparison to the sample MSA. This does not account for 2019 estimates of full-time work for women and men at the national level (see Methodology). For the sample's MSA, the MSA-level six-month cost of work distraction is $40,779,993 for women and $9,731,556 for men. The imputed MSA-level average six-month savings using treatment results from the U.S. is $27,328,429 for women and $7,262,307 for men. Considering these numbers, the costs to employers (aggregated yearly) in the sample MSA represent 0.073% of the total MSA GDP for 2019 (FRED Database: NGMP34980).

The cost and savings information presented in this section show that those with TMDs have moderate work distraction levels. This distraction decreases with decreases in TMD symptom severity due to effective TMD treatment (the Urbanek Splint).

Table 9
PER-PERSON COSTS TO EMPLOYERS FOR WORK DISTRACTION

				Per Person Average Cost Per Day of Work Distraction			Per Person Average Cost Per Six Months of Work Distraction			
	Count in Sample	Average Work Distraction	Average Hours of Work Per Day	Lower Bound of Hourly Wages	Mean of Hourly Wages	Upper Bound of Hourly Wages	Lower Bound of Hourly Wages	Mean of Hourly Wages	Upper Bound of Hourly Wages	Total Mean Lost Wages for Sample
Sample MSA										
Women	108	2.19	8.58	$59.39	$76.57	$93.77	$2,054.73	$2,649.24	$3,244.55	$286,118.21
Men	20	1.90	9.14	$56.73	$67.68	$78.65	$1,962.90	$2,341.87	$2,721.12	$46,837.40
Atlanta, GA										
Women			8.64	$68.08	$78.66	$89.26	$2,355.43	$2,721.48	$3,088.51	$293,919.73
Men			9.16	$65.69	$74.45	$83.29	$2,272.89	$2,575.98	$2,881.91	$51,519.57
Austin, TX										
Women			8.74	$62.01	$75.57	$89.13	$2,145.67	$2,614.84	$3,083.79	$282,402.94
Men			9.18	$58.12	$69.34	$80.57	$2,011.11	$2,399.25	$2,787.78	$47,984.94
Columbus, OH										
Women			8.55	$61.23	$76.74	$92.22	$2,118.63	$2,655.36	$3,190.66	$286,778.69
Men			9.08	$56.06	$68.71	$81.39	$1,939.61	$2,377.30	$2,816.10	$47,545.95
New York, NY										
Women			8.66	$84.78	$93.19	$101.60	$2,933.28	$3,224.32	$3,515.27	$348,226.15
Men			9.11	$80.31	$87.78	$95.20	$2,778.87	$3,037.20	$3,294.05	$60,744.01
Pheonix, AZ										
Women			8.63	$65.46	$77.76	$90.05	$2,264.78	$2,690.43	$3,115.81	$290,566.39
Men			9.01	$60.82	$69.16	$77.52	$2,104.27	$2,392.81	$2,682.05	$47,856.10
Seattle, WA										
Women			8.63	$64.36	$76.00	$87.61	$2,226.98	$2,629.50	$3,031.37	$283,985.67
Men			8.93	$60.66	$69.17	$77.67	$2,098.84	$2,393.11	$2,687.55	$47,862.23

Source: Author's Calculations using ACS 2019 data

Table 10
MSA-LEVEL COSTS AND SAVINGS FOR EMPLOYERS DUE TO WORK DISTRACTION

		Employed[1]	Women (50%)	Full time[2]	4.8% with Pain Around the TMJ[3,4]	Per Person Average Cost Per Six Months of Work Distraction	Per MSA Average Cost Per Six Months of Work Distraction	Per Person Average Savings Per Six Months of Work Distraction After US	Per MSA Average Savings Per Six Months of Work Distraction After US
Sample MSA									
	All	1,057,176							
	Women		528,588	395,912	15,393	$2,649.24	$40,779,993	$1,775.37	$27,328,429
	Men		528,588	455,643	4,155	$2,341.87	$9,731,556	$1,747.65	$7,262,307
Atlanta, GA									
	All	3,000,035							
	Women		1,500,017	1,123,513	43,682	$2,721.48	$118,880,150	$1,804.07	$78,805,580
	Men		1,500,017	1,293,015	11,792	$2,575.98	$30,376,702	$1,910.60	$22,530,314
Austin, TX									
	All	1,205,590							
	Women		602,795	451,493	17,554	$2,614.84	$45,901,111	$1,724.05	$30,264,025
	Men		602,795	519,609	4,739	$2,399.25	$11,369,640	$1,788.11	$8,473,568
Columbus, OH									
	All	1,066,992							
	Women		533,496	399,588	15,536	$2,655.36	$41,253,645	$1,745.76	$27,122,091
	Men		533,496	459,874	4,194	$2,377.30	$9,970,497	$1,765.08	$7,402,808
New York, NY									
	All	3,913,047							
	Women		1,956,524	1,465,436	56,976	$3,224.32	$183,709,141	$2,114.88	$120,497,822
	Men		1,956,524	1,686,523	15,381	$3,037.20	$46,715,462	$2,282.18	$35,102,345
Pheonix, AZ									
	All	2,382,993							
	Women		1,191,497	892,431	34,698	$2,690.43	$93,351,750	$1,773.52	$61,536,953
	Men		1,191,497	1,027,070	9,367	$2,392.81	$22,413,115	$1,760.29	$16,488,397
Seattle, WA									
	All	2,100,717							
	Women		1,050,358	786,718	30,588	$2,629.50	$80,430,039	$1,719.00	$52,580,056
	Men		1,050,358	905,409	8,257	$2,393.11	$19,760,711	$1,764.61	$14,570,970

Source: Author's Calculations

[1]BLS Databases: Nashville, TN (LAUMT473498000000006); Atlanta, GA (LAUMT131206000000005); Austin, TX (LAUMT481242000000006); Columbus, OH (LAUMT391814000000006); New York, NY (Special series: https://www.bls.gov/regions/new-york-new-jersey/data/xg-tables/ro2xgcesnyc.htm); Pheonix, AZ (LAUMT043806000000006); Seattle, WA (LAUMT534266000000004)

[2]BLS (2020); [3]NASEM (2020); [4]Durham et al. (2016b)

IMPLICATIONS AND LIMITATIONS

A limitation of this paper is the lack of work information for individuals in the sample, and there is a reliance on imputed values from Census data. To account for this limitation, the study matches as many variables as possible for wage estimates (e.g., city, age, full-time status, and gender). Hayes et al. (2013) use known occupations to impute wage estimates for the cost of work distraction. Even with imputed wage estimates, our estimates are within the ballpark of work distraction estimates found in prior research (Breckons et al., 2018; Edmeads and Mackell, 2002).

This paper concludes that TMD methods that target painful TMD symptoms are more likely to reduce work distraction and, subsequently, the costs of TMD-related work distraction to employers. This implies that this type of chronic pain intervention is successful in reducing the costs of work distraction for firms. The work distraction cost estimates imply that for the sample MSA, the effects of TMD symptoms make up a sizable portion of the total MSA GDP for 2019.

Previous research confirms that our human capital method may lead to estimates that are a lower bound than the true costs of work distraction due to chronic pain, as the type of firm (e.g., teamwork-based) is shown to have multiplying effects (Pauly et al.,2008). Managers of teamwork-based firms have more of an incentive to be aware of the reasons and solutions for workplace presenteeism based on illness or pain. Reducing the days of pain employees work increases the productivity of the team and the firm.

CONCLUSION

This paper finds the severity of painful TMD symptoms drives workplace distraction, over and above the severity of non-painful TMD symptoms. The OLS findings show that a one-unit increase in painful symptom severity is associated with a 36% increase in WD. The corresponding effect of non-painful symptom severity is negative and is about a third of the impact of the effect of painful symptoms (-12%). We consistently found a counterintuitive negative effect of non-painful symptoms on WD, which points toward a need for a better measurement of non-painful symptoms. Additionally, the larger effect for painful symptoms carries through in the models for HWD and AWD. For HWD, a one-unit increase in painful symptom severity is associated with a 64% increase in the probability of an individual having HWD. For AWD, a one-unit increase in painful symptom severity is associated with individuals being almost three times as likely to have AWD (probability increases by 275%). We also found some significant results by gender and age, where women and older workers are less likely to report HWD or AWD.

The per-person six-month cost estimates for work distraction for those in the sample are $2,649 for women (95% CI: $2,055 to $3,245) and $2,342 for men (95% CI: $1,963 to $2,721). This leads to for the total sample (women and men) a cost of $332,955 and for the total MSA cost of about $50 million for TMD-related WD. The per-person indirect work costs due to pain are higher than those found for individuals with migraines ($1,010 in 2019 dollars, Edmeads and

Mackell, 2002) and those with COFP ($2,059 in 2019 dollars, Breckons et al., 2018). Using the reduction in WD after treatment, the per-person six-month savings estimates for those in the sample are $1,775 for women (95% CI: $1,347 to $2,205) and $1,748 for men (95% CI: $1,464 to $2,031), implying a total savings of $226,693 to employers due to a reduction in WD after treatment for those in our sample. The total MSA estimated savings for a reduction in WD is about $34 million.

In conclusion, TMD-related symptoms impact an individual's level of work distraction, which leads to an increase in costs for employers. A reduction in the severity of TMD-related symptoms implies a decrease in work distraction and the costs of work distraction. Managers who are aware of this novel treatment for TMDs could save their employees days of working in pain and save their firms days of lower productivity, improving workforce satisfaction and profitability.

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APPENDIX

Table A1
Range Categories for Length of Time with Diagnosis and Length of Time with Symptoms Measures

How long have you been diagnosed with a TMD (temporomandibular disorder)?

	Midpoint Used	n	Total	Percent of Total
Less than 1 year	0.5	11	127	9%
1 to 3 years	1.5	39	127	30%
4 to 6 years	5	28	127	22%
7 to 10 years	8.5	18	127	14%
11 to 15 years	13	7	127	5%
16 to 20 years	18	6	127	5%
More than 20 years	20	19	127	15%

How long had you experienced your TMD symptoms before you were diagnosed with a TMD?

	Midpoint Used	n	Total	Percent of Total
Less than 1 year	0.5	15	127	12%
1 to 3 years	1.5	32	127	25%
4 to 6 years	5	22	127	17%
7 to 10 years	8.5	21	127	16%
11 to 15 years	13	12	127	9%
16 to 20 years	18	10	127	8%
More than 20 years	20	16	127	13%

Source: Author's Calculations using survey data

Table A2
Treatment Categories by Frequency in Sample

Treatment	n	Percent of total
Bite splints or occlusal guards	48	37.8%
Never treated for TMD symptoms	47	37.0%
Prescription medication	37	29.1%
Massage therapy	32	25.2%
Chiropractic	24	18.9%
Physical therapy	12	9.4%
Other	11	8.7%
Occlusion correction or braces	10	7.9%
Acupuncture	6	4.7%
Botox	6	4.7%
Surgery	3	2.4%

Source: Author's Calculations using survey data

Table A3
Comorbidities by Frequency in Sample

Comorbidity	n	Percent of total
Back neck and joint pain	76	59.8%
Headaches	76	59.8%
Respiratory conditions e g sinus trouble allergies or breathing difficulties	38	29.9%
Sinusitis	33	26.0%
Tinnitus	31	24.4%
Sleep disorders (insomnia or poor sleep quality)	30	23.6%
Hypertension	27	21.3%
Somatic and psychological symptoms (depression anxiety or post traumatic stress disorder)	25	19.7%
Vertigo	21	16.5%
Irritable bowel syndrome	16	12.6%
Osteoarthritis in body joints other than the TMJ	16	12.6%
Asthma	13	10.2%
Endometriosis	12	9.4%
Chronic fatigue syndrome	6	4.7%
Rheumatoid arthritis in body parts other than the TMJ	6	4.7%
Juvenile idiopathic arthritis in body parts other than TMD	0	0.0%
Vulvodynia	0	0.0%
Ankylosing spondylitis in body parts other than TMJ	ND	
Ehlers Danlos syndrome	ND	
Fibromyalgia	ND	
Interstitial cystitis painful bladder	ND	
Neural sensory conditions	ND	
Poor nutrition due to limited jaw function and or pain while chewing	ND	
Psoriatic arthritis in body parts other than the TMJ	ND	
Sjogren s syndrome	ND	
Systemic lupus erythematosus	ND	

Note: Comorbidity categories are from NASEM (2020). Categories with N.D. have a positive number of respondents, but less than six reported these comorbidities. For privacy, we do not report the frequencies for these comorbidities. N.D. is “not disclosed.”

Table A4
Imputed Hourly Wages and Daily Hours Worked by Gender, Age, and City

		Atlanta, GA		Austin, TX		Columbus, OH		Nashville, TN		New York, NY		Phoenix, AZ		Seattle, WA		Topeka, KS	
Gender	Age	Wage/Hr	Hrs/Day	Wage/Hr	Hrs/Day	Wage/Hr	Hrs/Day	Wage/Hr	Hrs/Day	Wage/Hr	Hrs/Day	Wage/Hr	Hrs/Day	Wage/Hr	Hrs/Day	Wage/Hr	Hrs/Day
Female	20	9.14	8.12	8.98	7.94	9.82	8.03	9.01	8.07	10.31	8.30	10.28	8.26	11.13	8.34	9.02	9.60
Female	22	11.07	8.17	11.66	8.16	10.95	8.11	11.92	8.24	13.59	8.29	13.62	8.22	13.42	8.42	6.81	10.00
Female	23	14.16	8.46	14.76	8.33	14.51	8.26	14.75	8.28	19.16	8.52	14.53	8.38	18.02	8.27	19.01	8.53
Female	24	16.72	8.29	19.19	8.49	18.29	8.49	17.18	8.37	20.63	8.50	16.12	8.51	19.86	8.40	10.42	8.00
Female	25	20.39	8.45	21.35	8.39	20.93	8.24	20.76	8.45	24.50	8.61	18.00	8.27	26.02	8.30	16.38	8.00
Female	25	20.39	8.45	21.35	8.39	20.93	8.24	20.76	8.45	24.50	8.61	18.00	8.27	26.02	8.30	16.38	8.00
Female	26	21.55	8.72	24.42	8.46	20.25	8.40	19.50	8.36	26.86	8.63	18.99	8.46	24.26	8.61	17.19	8.20
Female	27	19.72	8.48	21.94	8.39	21.04	8.50	21.26	8.50	26.86	8.58	19.03	8.53	28.52	8.69	15.59	8.24
Female	28	22.71	8.63	25.39	8.47	20.96	8.41	19.11	8.40	28.07	8.76	20.25	8.37	29.05	8.55	15.39	8.53
Female	29	24.83	8.53	26.10	8.53	20.97	8.40	22.93	8.70	31.16	8.74	22.04	8.50	30.26	8.70	17.68	8.40
Female	29	24.83	8.53	26.10	8.53	20.97	8.40	22.93	8.70	31.16	8.74	22.04	8.50	30.26	8.70	17.68	8.40
Female	30	23.47	8.62	29.08	8.82	24.86	8.29	24.04	8.61	30.87	8.81	22.52	8.41	29.24	8.60	21.24	8.33
Female	31	26.55	8.69	23.30	8.62	25.78	8.62	27.67	8.45	33.12	8.76	23.14	8.45	30.78	8.69	15.93	9.00
Female	32	25.60	8.68	30.11	8.53	26.34	8.80	26.76	8.55	36.08	8.56	23.14	8.51	33.10	8.68	29.98	9.17
Female	33	25.36	8.66	29.20	8.65	25.57	8.23	22.01	8.69	36.00	8.73	26.08	8.45	33.99	8.56	17.65	8.29
Female	34	26.67	8.63	27.60	8.64	24.65	8.43	26.12	8.34	39.35	8.67	24.51	8.74	37.46	8.47	31.01	8.71
Female	35	30.35	8.65	27.99	9.01	31.73	8.51	23.34	8.82	39.00	8.75	30.46	8.76	35.68	8.67	16.10	9.00
Female	36	33.58	8.55	32.77	8.63	29.67	8.55	31.17	8.71	40.97	8.60	26.26	8.52	39.78	8.83	35.07	8.33
Female	37	32.76	8.72	31.31	8.72	29.19	8.77	29.09	8.54	37.70	8.68	29.19	8.52	38.48	8.46	21.90	9.05
Female	38	30.96	8.66	36.02	8.68	35.46	8.40	25.69	8.68	37.87	8.74	28.16	8.74	37.94	8.80	27.66	8.33
Female	39	31.18	8.53	29.83	8.81	27.45	8.75	30.75	8.68	40.87	8.64	28.36	8.86	38.99	8.77	22.90	8.36
Female	40	32.10	8.59	35.66	8.71	29.64	8.57	26.57	8.79	38.37	8.59	28.26	8.57	37.75	8.39	17.41	8.91
Female	41	31.17	8.65	43.62	9.02	29.20	8.22	30.28	8.41	44.09	8.67	30.58	8.68	44.61	8.80	24.65	8.71
Female	42	32.39	8.64	30.58	8.64	33.08	8.47	29.68	8.87	43.03	8.64	28.54	8.67	35.50	8.78	29.99	8.80
Female	43	30.97	8.67	33.94	8.87	28.10	8.98	26.04	8.47	40.23	8.68	28.82	8.40	40.04	8.64	18.84	8.65
Female	44	32.65	8.60	31.41	8.98	32.11	8.93	27.32	8.43	40.73	8.59	31.53	8.93	45.17	8.71	25.57	8.00
Female	46	33.43	8.73	37.67	8.77	32.03	8.58	26.93	8.51	41.16	8.68	28.75	8.96	39.63	8.92	21.01	8.33
Female	47	31.88	8.75	32.66	8.55	34.85	8.85	24.78	8.83	40.84	8.67	30.92	8.60	36.54	8.76	15.84	8.18
Female	48	34.08	8.71	34.79	8.66	29.91	8.49	33.84	8.60	40.99	8.65	33.15	8.93	38.29	8.81	24.53	8.70
Female	49	31.47	8.70	32.54	8.83	35.11	8.49	32.11	8.42	42.73	8.80	31.47	8.81	42.15	8.67	23.51	8.61
Female	50	31.30	8.80	40.07	8.95	32.24	8.60	28.17	8.63	40.85	8.62	28.55	8.78	37.85	8.55	25.34	9.23
Female	51	30.31	8.55	32.59	8.84	26.97	8.50	26.47	8.65	39.94	8.72	32.61	9.02	41.32	8.75	13.94	7.89
Female	52	31.33	8.76	34.51	9.07	27.33	8.97	28.21	8.63	38.27	8.66	29.09	8.67	44.46	8.79	19.53	8.00
Female	53	32.43	8.75	28.63	8.93	34.34	8.66	31.60	8.91	40.26	8.71	29.85	8.53	32.60	8.59	26.09	8.27
Female	54	31.36	8.69	24.06	8.84	32.95	8.57	29.26	8.93	39.66	8.74	27.59	8.74	39.59	8.65	27.86	8.63
Female	55	32.31	8.98	32.05	8.82	27.83	8.55	27.88	8.71	37.59	8.74	28.03	8.70	33.20	8.63	15.16	8.23
Female	57	28.40	8.67	29.57	9.06	30.08	8.57	32.21	8.64	40.37	8.65	27.06	8.72	32.12	8.47	20.42	7.92
Female	58	29.07	8.72	31.35	8.57	28.02	8.59	28.56	8.58	38.40	8.58	31.42	8.60	35.68	8.73	20.16	8.52
Female	59	29.80	8.50	31.60	8.99	24.24	8.57	27.94	8.81	38.66	8.64	32.56	8.76	35.95	8.66	22.12	9.40
Female	60	30.30	8.63	32.84	8.84	26.87	8.54	24.43	8.48	39.26	8.76	28.87	8.79	34.89	8.46	16.78	8.38
Female	61	29.10	8.78	25.45	8.37	31.90	8.43	26.84	8.33	37.04	8.62	26.07	8.93	35.32	8.71	21.38	8.67
Female	62	27.41	8.66	34.58	8.58	34.22	8.50	26.97	8.75	37.10	8.62	23.57	9.26	30.66	8.66	20.70	8.50
Female	63	31.75	8.40	28.12	8.70	33.81	9.18	24.29	8.46	37.42	8.67	28.55	8.76	43.18	8.80	15.56	8.00
Female	64	31.06	8.72	23.08	8.65	27.10	8.48	24.97	8.36	35.95	8.49	28.91	8.53	39.89	8.64	22.40	8.55
Female	65	25.91	8.73	22.66	9.06	29.45	8.94	37.45	8.34	39.80	8.58	30.25	8.62	31.77	8.77	19.79	8.00
Female	66	26.33	8.50	35.01	8.82	23.63	8.09	42.34	8.29	34.89	8.49	27.10	9.02	31.57	8.83	37.15	8.00
Female	68	29.00	8.49	33.43	9.10	29.27	8.18	26.22	8.64	41.52	8.57	28.34	8.44	38.06	8.50		
Male	23	14.91	8.72	17.34	8.77	14.33	8.91	15.93	8.96	18.13	8.75	15.00	8.59	21.79	8.76	12.82	8.55
Male	33	33.51	9.14	33.43	8.92	31.80	8.78	32.48	9.04	39.11	9.09	29.56	8.96	42.76	8.98	25.76	8.38
Male	35	32.24	9.16	38.79	9.43	30.91	9.18	27.16	9.12	44.27	9.17	33.48	8.85	52.80	9.01	25.11	9.63
Male	37	38.23	8.94	43.99	9.06	36.49	9.06	27.49	9.22	49.06	9.10	34.55	9.03	52.29	9.02	18.05	10.36
Male	39	34.53	9.14	45.20	9.32	34.53	9.10	37.38	9.22	51.48	9.16	32.93	9.21	51.01	8.92	45.10	8.47
Male	44	40.39	9.23	45.68	9.23	44.86	8.88	38.09	9.01	52.68	9.06	34.20	9.03	62.39	8.99	23.06	9.68
Male	45	46.89	9.31	47.23	9.10	44.76	9.03	33.05	9.13	53.21	9.16	33.81	9.05	52.37	8.86	29.89	9.71
Male	54	44.51	9.28	46.26	9.33	32.62	9.07	36.42	9.16	54.39	9.20	39.18	9.26	54.55	8.94	31.71	9.60
Male	57	48.12	9.17	48.37	8.72	39.16	9.11	43.17	9.17	49.33	9.17	41.82	8.94	55.18	9.22	33.67	9.89
Male	58	42.63	9.22	42.18	9.29	40.10	9.13	34.28	9.05	53.87	9.13	41.29	9.29	45.84	9.09	28.64	8.60
Male	59	46.17	9.46	57.62	9.34	38.18	8.97	39.17	9.20	50.23	9.14	42.26	9.23	55.91	9.06	30.96	8.67
Male	63	42.65	9.23	42.28	9.59	44.84	9.00	38.49	9.02	51.01	9.10	38.72	9.15	39.47	8.92	18.71	8.50
Male	64	44.63	9.11	44.02	9.05	51.82	9.45	40.88	9.12	47.46	9.02	46.35	9.01	49.57	8.87	16.00	9.82
Male	70	33.15	8.50	43.76	9.06	38.08	9.43	52.36	8.91	58.04	8.96	38.35	8.42	45.54	8.55	25.70	8.20
Male	73	46.48	9.59	25.63	8.67	18.85	8.94	55.06	9.63	52.43	9.13	28.23	8.80	35.95	8.56		

Source: Author's Calculations using ACS 2019 Data