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# Prevalence of Painful Temporomandibular Disorders and Overlapping Primary Headaches Among Young Adults

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## ABSTRACT

**Background:** Large population-based estimates of the prevalence of painful temporomandibular disorders (p-TMD) utilising standardised screening tools are scarce and have not investigated the prevalence of overlapping primary headaches. We aimed to estimate the prevalence of p-TMD in a large population of young adults (18 to 23 years) and to estimate the co-occurrence of p-TMD and two primary headaches, migraine and tension-type headache (TTH). The study also aimed to examine the extent of psychological (PHQ-4) and physical (PHQ-15) comorbidities and report prevalence across three gender categories (*women*, *men* and *other*).

**Methods:** Survey data from the Danish National Birth Cohort were collected ($n = 11{,}982$), in a cross-sectional observational design. A sensitivity analysis was conducted to address participation bias, revealing minimal impact on the estimates.

**Results:** The overall prevalence of p-TMD was 26.4% with gender-specific prevalence of *women:* 31.5%, *other:* 39.2% and *men:* 16.8%. Among those with p-TMD, 80.5% reported headaches at least once a month, and 13.8% over 15 days monthly. For the p-TMD individuals with a medical headache diagnosis, 31.9% experienced TTH and 10.9% migraine. The study also identified a higher proportion of moderate/severe psychological distress and physical symptoms in the p-TMD group compared to the non-p-TMD group. Logistic regression revealed a positive association between PHQ-4 and p-TMD, modified by gender ($p = 0.016$).

**Conclusions:** High overall prevalence of p-TMD and overlapping primary headaches was found in young adults. In addition, the study reports gender-specific associations between p-TMD, psychological distress and physical comorbidities indicating that this association is stronger for men than for women.

**Significance Statement:** This study found a higher-than-expected prevalence of painful temporomandibular disorders in young adults. It is based on a large population cohort and used standardised and validated screening tools. The study also reported common co-occurrence of primary headaches and explored gender differences. The study raises awareness for a possibly underestimated health burden in young individuals, particularly among individuals experiencing psychological distress and multiple physical symptoms.

## 1 | Introduction

Painful temporomandibular disorders (p-TMD) are painful conditions affecting the temporomandibular joints (TMJ) and/or masticatory muscles. They are the most common chronic orofacial pain and contribute significantly to healthcare service utilisation (Durham et al. 2016; Maixner et al. 2011). In adults, the prevalence of p-TMD is estimated to range from 3% to 10% in men and 6% to 15% in women (LeResche 1997). p-TMD is associated with various degrees of disability and reduced quality of life, with an estimated 3% of the Western population actively seeking management of TMD-related problems (Dahlström and Carlsson 2010; Magnusson et al. 1991, 2002). Additionally, there is a significant overlap between p-TMD and primary headaches, with studies reporting that 56.1% of patients with headache, particularly migraine and tension-type headache (TTH), or a combination of both, also have TMD (Ballegaard et al. 2008; Gonçalves et al. 2010). p-TMD has been identified as a risk factor for headache development, and headache status can predict the development of p-TMD (Marklund et al. 2010; Tchivileva et al. 2017). The severity of both p-TMD and headaches increases when they are comorbid, and addressing both conditions simultaneously leads to improved treatment outcomes (Goncalves et al. 2013; Gonçalves et al. 2011).

Prevalence studies regarding p-TMD historically lack consistent definitions and terminology (Drangsholt and LeResche 1999). Large population-based estimates utilising standardised screening tools (Lovgren et al. 2016) are scarce and have not investigated the prevalence of overlapping primary headaches. Moreover, studies on orofacial pain (Häggman-Henrikson et al. 2020) have primarily focused on biological differences between males and females. This means that individuals who identify with a gender different from their biological sex at birth (male or female), and individuals who do not strictly identify as women or men, may have been overlooked. However, gender diverse individuals face unique social and healthcare disparities that may impact their pain experience (Borgogna et al. 2019; Pace et al. 2021). Consequently, this may influence the prevalence of orofacial pain, headaches and related disability in this particular group. Gender disparities in pain research are well documented, and it has recently been proposed to include diverse gender identities to ensure more equitable and comprehensive research (Palermo et al. 2023).

Therefore, the primary aim of the present study was to estimate the prevalence of p-TMD among a large population within the Danish National Birth Cohort (DNBC). In addition, the study aimed to estimate the prevalence of self-reported medical diagnoses of primary headaches, specifically TTH and migraine, in individuals with p-TMD. Finally, the study aimed to report the prevalence of p-TMD across diverse gender groups (*men, women and other*) and to examine the extent of current disability through the evaluation of psychological and physical comorbidities.

## 2 | Methods

### 2.1 | Study Design and Participants

We used a cross-sectional observational design. The study population is part of the DNBC, which enrolled 101,042 pregnancies across Denmark from 1996 to 2002, covering around 30% of the country's pregnancies during that period (Olsen et al. 2001; Statens Serum Institut About the DNBC n.d.). The data collection for the present study was performed concurrently with a parallel investigation, which aimed to examine the role of nutrition as a potential risk factor for p-TMD. For that reason, the sub-sample of the DNBC for this study consisted of individuals who responded to a food frequency questionnaire (FFQ) at age 14 (Bjerregaard et al. 2019) and were ≥ 18 years old at the time of our data collection. The FFQ at age 14 did not assess or inquire about pain or TMD-related issues. A total of 33,412 individuals were invited to participate. All participants were born in Denmark and aged between 18 and 23 years. The lower age limit was defined by sufficient age to consent to participate in this study; there was no upper age limit, that is, the oldest participants were 23 years old at the time of the study.

In 2021, invitations with questionnaire links were sent via e-boks, Denmark's mandatory digital postbox for citizens aged 15+. Non-responders received three digital reminders at 7-day intervals, followed by a final reminder via e-boks and paper mail after 1 month.

### 2.2 | Survey

The survey consisted of questions designed to screen for p-TMD, headaches and psychological and physical aspects of pain, as follows:

- The long version of the TMD pain screener, which is a 6-item validated questionnaire with high sensitivity and specificity (≥ 0.95) (Gonzalez et al. 2011), was used to identify cases: positive screening for p-TMD and non-cases: negative screening for p-TMD.

The screener is available online (https://inform-iadr.com/wp-content/uploads/2024/01/TMD-Pain-Screener_revised-10Aug2011.pdf).

- Psychosocial distress and physical symptoms were assessed using the validated patient health questionnaires 4 and 15, PHQ-4 and PHQ-15, respectively. The PHQ-4 screens for 'psychological distress' due to anxiety and/or depression (Löwe et al. 2010). PHQ-4 scores > 6 indicate moderate psychological distress, while > 9 suggest severe distress (max 12) (Ohrbach and Knibbe 2016). The PHQ-15 is used to assess non-specific physical symptoms (Kroenke et al. 2002). Cut-offs of 5, 10 and 15 represent low, medium and high somatic severity (max 30) (Ohrbach and Knibbe 2016). Cut-offs of ≥ 6 for PHQ-4 and ≥ 10 for PHQ-15 were used to categorise moderate/severe levels of psychological distress and physical symptoms.
- Self-reported headache presence, frequency and medical diagnosis of primary headaches were assessed through five non-validated questions, as follows: lifetime headache experience (*yes/no*), the 'number of headache days in the past 12 months', and consultation with medical doctor and/or a healthcare professional regarding headaches; participants

who answered 'yes' to having had a consultation with a healthcare professional regarding their headaches were asked about the medical diagnosis they received (*migraine, TTH, both migraine and TTH, other*). In Denmark, all healthcare professionals (general practitioners, physicians in training, neurologists and paediatricians) in both private and public healthcare settings, adhere to the guidelines outlined in the 'Reference Programme: Diagnosis and Treatment of Headache Disorders and Facial Pain' (Schytz et al. 2020). Thus self-report of a medical diagnosis of migraine and/or TTH was used to assess the prevalence of the two most common primary headaches. To avoid categorising almost the entire population as having a significant headache (International Headache Society 2018), a cut-off of ≥1 day of headache per month was used to assess the overall prevalence of headaches. This cut-off includes both frequent and chronic TTH and/or migraine (International Headache Society 2018). According to ICHD-3 (International Headache Society 2018), a cut-off of ≥15 days/month on average is used to define chronic TTH and/or migraine. This cut-off was used to report PHQ-4 and PHQ-15 scores across the different headache diagnoses.

- Participants screening positive for p-TMD and/or having headaches at least 1 day per month evaluated their pain and pain-related disability using the graded chronic pain scale (GCPS) (Von Korff et al. 1992). The GCPS incorporates measures of pain frequency, intensity (pain right now, worst pain and average pain), duration and interference with daily functioning. A characteristic pain intensity (CPI) score was calculated from the three pain intensity questions (range 0–100). The GCPS encompasses five chronic pain grades: 0 = no pain, I = low pain intensity, without disability, II = high pain intensity, without disability, III = high pain intensity moderately limiting, IV = high pain intensity severely limiting. We dichotomized the GCPS into low impact or high impact pain, with low impact including grades 0 to IIa and high impact including grades IIb to IV (Dworkin and LeResche 1992). Within grade II, the low impact group (IIa) comprised individuals with high pain intensity (5 or higher; CPI ≥ 50) but no disability points, while the high impact group (IIb) consisted of individuals with the same pain intensity level (5 or higher; CPI ≥ 50) but with low disability points (less than 3) (Dworkin and LeResche 1992).
- Finally, participants were asked about their gender identification, prompting them to specify their identification as *men*, *women* or *other*. At birth, the biological sex of all Danish citizens is registered as female or male. Individuals whose gender identification (man or woman) aligned with their biological sex (male or female) were categorised as belonging to the respective *men* or *women* gender categories. For the purposes of this study, individuals identifying with a gender divergent from their biological sex (individuals assigned male at birth and identifying as women, and individuals assigned female at birth and identifying as men) or individuals selecting the gender category *other* were categorised as belonging to the *other* gender category.

## 2.3 | Statistical Analysis

Anonymized data was exported to Stata/MP 17.0. The analysis was limited to individuals with complete data on the TMD pain screener ($n = 11{,}982$).

Prevalence estimates were calculated: Prevalence = (number of cases with the condition at a specific point in time)/ (total population at that specific point in time). Prevalence estimates and 95% confidence intervals (CI) were calculated separately for p-TMD cases and non-cases, and within each gender category: *men*, *women* and *other*. Crude and gender-adjusted logistic regression analyses were performed to examine the association between PHQ-4 and p-TMD, and PHQ-15 and p-TMD. Analysis of the potential interaction between PHQ-4 and gender, and PHQ-15 and gender, was also conducted. $p$-values $< 0.05$ were considered significant. For the regression analysis, the overall PHQ-15 score was recalculated after excluding the items 'menstrual cramps or other problems with your periods' and 'headaches'. The overall PHQ-15 score was rescaled accordingly, and the same cutoff score of ≥10 was used to categorise moderate/severe physical symptoms. These changes were made to avoid overlap of symptoms reported in the PHQ-15 with the confounder and outcome variables.

## 2.4 | Sensitivity Analysis

To account for potential selection bias due to selective attrition, selection weights were included in the analyses. First, multivariable logistic regression was used to estimate the inverse probability of participating in the FFQ at age 14, including pregnancy information about the mother (age, socio economic status, smoking and pre-pregnancy body mass index) and child sex in the model. Second, multivariable logistic regression was performed to estimate the inverse probability of participating in this study survey, including the same predictors as in the first and adding information about the FFQ to the model. The two selection weights were multiplied to form a single selection weight, which was included in the regression analyses.

## 2.5 | Ethics

The study was approved by the Danish Data Protection Agency (DDPA) under the Aarhus University agreement jn.2016–051-000001, sn.1852. The DNBC was approved by the Committee on Health Research Ethics in the Capital Region of Denmark jn. (KF) 01–471/94 and by the DDPA under the common agreement for Statens Serum Institut, jn.2015-57-0102. The pregnant women enrolled at the start of the DNBC provided written informed consent for themselves and on behalf of their children. For our subsequent data collection, all methods were carried out in accordance with relevant guidelines and regulations, including the General Data Protection Regulation, which did not mandate written informed consent because our research was conducted exclusively through anonymised survey and all participants were above the Danish age of majority.

## 3 | Results

In total 11,982 (35.8%) individuals completed the TMD pain screener.

In this study, a total of 102 individuals were in the gender category *other*; among these, 63.7% ($n = 65$) were registered female at birth and 36.3% ($n = 37$) were registered male at birth.

The prevalence of p-TMD was 26.4% (95% CI, 25.6–27.2), $n = 3163$, Figure 1. Within each gender category, the prevalence of p-TMD was as follows: *women* 31.5% (2418/7681), *men* 16.8% (705/4199) and *other* 39.2% (40/102). Never having had a headache was reported by 2.4% of all participants, who completed the TMD pain screener and answered to the question 'have you ever had a headache?' ($n = 11{,}804$). The prevalence of headaches ≥1 days per month was 62.6% (95% CI, 61.7–63.5), $n = 7389$, and the prevalence of headaches <1 day per month was 35% (95% CI, 34.1–35.9), $n = 4137$, Figure 1. Within each gender category, the prevalence of headaches ≥1 day per month was: *women* 72.8% (5436/7471*); *men* 47.5% (1878/3956*); and *other* 75.8% (75/99*). ≈*Exact *n* are not disclosed to safeguard privacy and confidentiality due to $n \leq 5$ for the gender distribution in the variable 'never had a headache'.

Furthermore, out of the participants who reported experiencing ≥1 headache days per month, 13.8% ($n = 1016$) reported headaches more than 15 days per month; in other words, within our overall study population, 8.5% of individuals were found to experience headaches >15 days per month. The gender distribution for individuals reporting headaches >15 days per month was: *men* 14.7% (95% CI, 12.5%–17%), *other* 1.5% (95% CI, 0.8%–2.4%), *women* 83.8% (95% CI, 81.3%–86%).

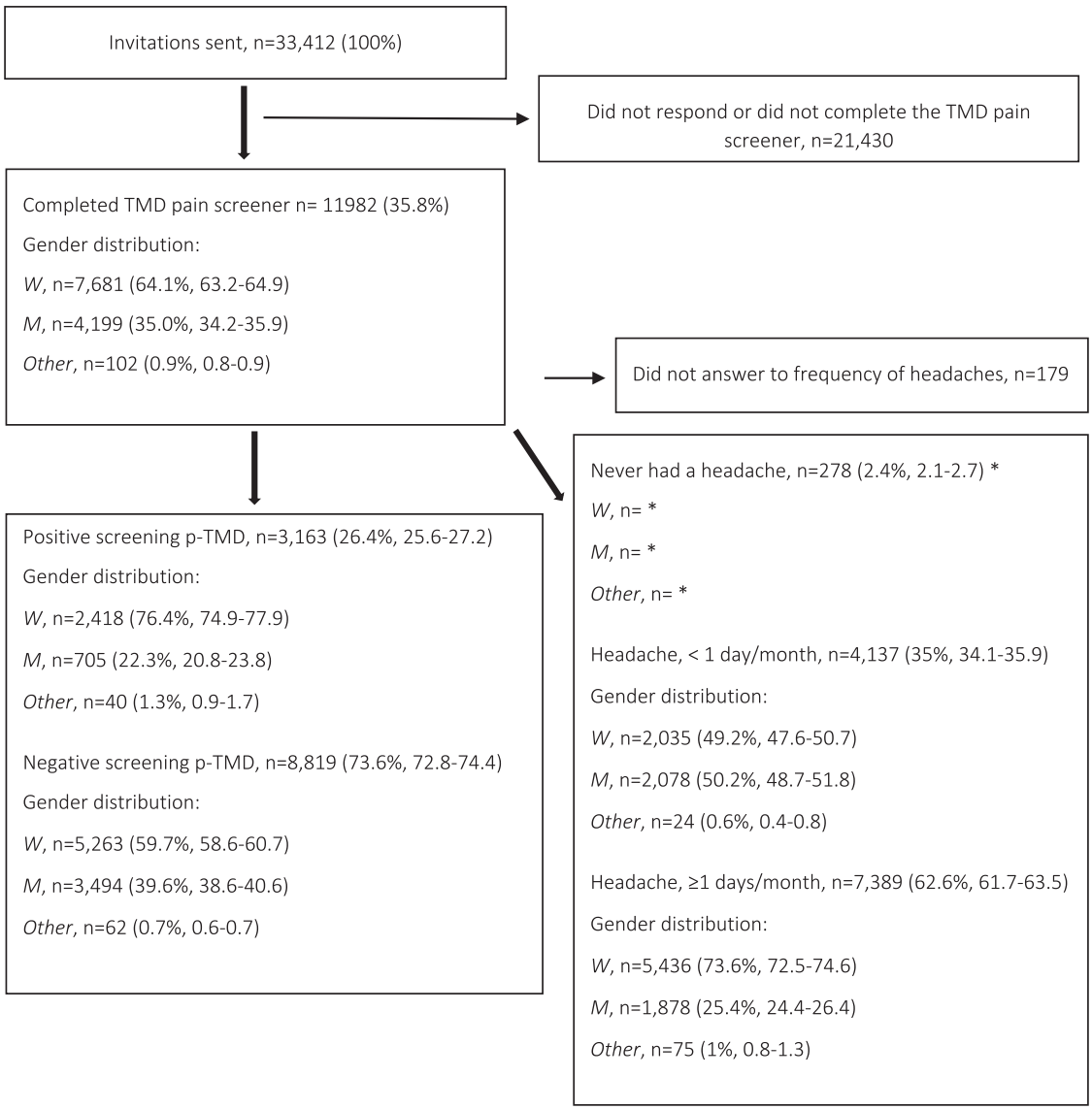


**FIGURE 1** | Prevalence and response rate. This table presents response rates, prevalence of positive and negative screening for painful temporomandibular disorders (p-TMD), prevalence of headaches categorised as <1 or ≥1 days per month, and gender distribution (*Women*, *Men* and *Other*). Prevalence was calculated as the proportion of participants who completed the TMD pain screener ($n = 11{,}982$) and reported headache frequency ($n = 11{,}803$). 95% confidence intervals are provided. 'p-TMD' denotes painful temporomandibular disorders, while 'W' and 'M' represent Women and Men, respectively. 'n' indicates the number of individuals, and '%' signifies the proportion relative to the total number of participants completing both. *Specific data for genders with fewer than 5 individuals are not disclosed to safeguard privacy and confidentiality.

Within those who screened positive for p-TMD and answered about the frequency of headaches ($n = 3127$), the prevalence of headaches ≥ 1 day per month was 80.5% (79.1%–81.9%), Table 1. Of these, 566 reported headaches occurring > 15 days per month (18.1% of individuals with p-TMD). Among those with > 15 headache days per month and positive screening for p-TMD, 393 had a medical consultation regarding their headaches. Of these, 18.3% ($n = 72$) reported diagnoses of both TTH and migraine; 7.6% ($n = 30$) reported a migraine diagnosis only; 34.6% ($n = 136$) reported TTH only, and 39.4% ($n = 155$) had other diagnoses.

Of the total individuals reporting ≥ 1 headache day per month, 32% (95% CI, 30.9%–33.1%) had seen a medical professional regarding their headaches. In this group, 26.3% (95% CI, 24.5%–28.1%) had a medical diagnosis of migraine and 41.3% (95% CI, 39.3%–43.3%) had a medical diagnosis of TTH, Table 2. Among p-TMD cases who had seen a medical professional because of headache ($n = 1075$), the prevalence of only reporting TTH was 31.9% (95% CI, 29.1%–34.8%), only reporting migraine was 10.9% (95% CI, 9.1%–12.9%), the prevalence of reporting both was 13.9% (95% CI, 11.9%–16.2%), and 43.3% (95% CI, 40.3%–46.3%) reported neither, Table 2. Gender distribution according to medical diagnosis of migraine and/or TTH is displayed in Table 3. In the total study population, 21.8% (95% CI, 21.1%–22.6%) of individuals reported both p-TMD and having headaches ≥ 1 day per month, while p-TMP and having headaches < 1 day per month was present in 4.8% (95% CI, 4.4%–5.2%), Table 4. The same pattern of higher prevalence of p-TMD and headaches compared to experiencing p-TMD alone was also seen within each gender, Table 4.

Descriptive statistics for PHQ-15 scores within the entire study population are as follows: median score 8, with an interquartile range (IQR) of 4 to 12. None/mild PHQ-15 scores were present in 62.6% ($n = 6833$), while moderate/severe scores were present in 37.4% ($n = 4082$) of all participants. Moderate/severe PHQ-15 scores were present in 50.9% ($n = 3553$) of *women*, 12.5% ($n = 481$) of *men*, and 51.6% ($n = 48$) of *other*. Moderate/severe PHQ-15 scores were present in 61.9% (95% CI, 60.1%–63.7%) of the p-TMD population, and in 28.8% (95% CI, 27.8%–29.8%) of individuals screening negative for p-TMD, Table 5. In summary, based on the confidence intervals above, it is indicated that moderate/severe scores on the PHQ-15 are more frequently observed in the presence of p-TMD than in the non-p-TMD group. Additionally, these scores appear to be less prevalent among *men* compared to *women* and *other*, irrespective of p-TMD screening status. For participants with p-TMD and moderate/severe PHQ-15 scores ($n = 1760$, 100%), the most frequently reported symptoms with high severity were: 58.6% ($n = 1032$) reported 'feeling tired or having low energy,' 40.6% ($n = 741$) reported 'headaches,' 35% ($n = 542$) reported 'menstrual problems,' 33.4% ($n = 587$) reported 'trouble sleeping,' and 33.1% ($n = 583$) reported 'back pain.' High severity for other PHQ-15 physical symptoms was reported by fewer than 30% of participants.

For the entire study population, descriptive statistics for PHQ-4 scores are as follows: median score 3, IQR of 1 to 3. None/mild PHQ-4 scores were present in 82.8% of participants, while 17% had moderate/severe scores. Moderate/severe PHQ-4 scores were seen in 20.3% ($n = 1412$) of *women*, 10.6% ($n = 406$) of *men* and 54.8% ($n = 51$) of *others*. Moderate/severe PHQ-4 scores were present in 27.5% (95% CI, 25.9%–29.2%) of p-TMD cases, and 13.5% (95% CI, 12.8%–14.3%) of individuals screening p-TMD negative, Table 5. In summary, descriptive data indicates a higher prevalence of *moderate/severe* PHQ-4 scores in individuals with p-TMD compared to those without p-TMD. Furthermore, these scores exhibit greater prevalence in the gender category *other* compared with both *women* and *men*, regardless of p-TMD screening status.

Tables S1 and S2 present PHQ-15 and PHQ-4 scores across p-TMD screening status and self-reported primary headache diagnosis, or > 15 headache days/month.

Crude logistic regression analysis showed a positive association between PHQ-4 and p-TMD (OR 2.43, 95% CI 2.19–2.69, $p < 0.001$), that is, the odds of experiencing P-TMD were 143% higher for *moderate/severe* PHQ4 scores compared to *none/mild* scores. After adjustment for gender, the positive association between PHQ-4 and p-TMD was slightly attenuated, OR 2.19, 95% CI 1.97–2.43, $p < 0.001$. In addition, the analysis revealed that gender significantly modified the association, p (interaction) = 0.016. The odds of experiencing p-TMD for individuals with *moderate/severe* PHQ-4 scores compared *to none/mild* scores were: *men* OR = 2.94, 95% CI 2.34–3.69, *other* OR = 2.40, 95% CI 1.01–5.71 and *women* OR = 2.01, 95% CI 1.79–2.28.

Crude logistic regression analysis showed a positive association between PHQ-15 and p-TMD (OR 3.57, 95% CI 3.24–3.94,

**TABLE 1** | Report of headache in the total study population and according to painful TMD screening.

| | | Painful TMD screening | |
|---|---|---|---|
| | **Total** | **p-TMD: yes** | **p-TMD: no** |
| | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** |
| Headache | | | |
| ≥ 1 day/month | 7389 (62.6, 61.7–63.5) | 2518 (80.5, 79.1–81.9) | 4871 (56.1, 55–57.1) |
| < 1 day/month | 4137 (35, 34.1–35.9) | 556 (17.8, 16.5–19.2) | 3581 (41.3, 40.3–42.3) |
| Never had a headache | 278 (2.4, 2.1–2.7) | 53 (1.7, 1.3–2.2) | 225 (2.6, 2.3–2.9) |
| Total | 11,804 (100) | 3127 (100) | 8677 (100) |

*Note:* p-TMD: yes, positive screening, and p-TMD: no, negative screening. Proportion (%) and 95% Confidence Intervals (CI).

**TABLE 2** | Report of tension-type headache and migraine in the total study population and according to painful TMD screening.

| | | Painful TMD screening | |
|---|---|---|---|
| | **Total** | **p-TMD: yes** | **p-TMD: no** |
| | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** |
| Consultation | | | |
| Yes | 2365 (32, 30.9–33.1) | 1076 (42.7, 40.8–44.8) | 1289 (26.5, 25.3–27.7) |
| No | 5024 (68, 66.9–69) | 1442 (57.3, 55.3–59.3) | 3582 (73.5, 72.2–74.8) |
| Total | 7389 (100)[a] | 2518 (100) | 4871 (100) |
| Migraine | | | |
| Yes | 622 (26.3, 24.5–28.1) | 267 (24.8, 22.3–27.5) | 355 (27.5, 25–29.9) |
| No | 1743 (73.7, 71.9–75.5) | 808 (75.2, 72.5–77.7) | 935 (72.5, 70–74.9) |
| Total | 2365 (100)[a] | 1075 (100) | 1290 (100) |
| TTH | | | |
| Yes | 977 (41.3, 39.3–43.3) | 493 (45.9, 42.9–48.9) | 484 (37.5, 34.8–40.2) |
| No | 1388 (58.7, 56.7–60.7) | 582 (54.1, 51.1–57.2) | 806 (62.5, 59.8–65.2) |
| Total | 2365 (100)[a] | 1075 (100) | 1290 (100) |
| Migraine/TTH | | | |
| None | 1052 (44.4, 42.4–46.5) | 465 (43.3, 40.3–46.3) | 587 (45.4, 42.7–48.2) |
| Both | 284 (12, 10.7–13.4) | 150 (13.9, 11.9–16.2) | 134 (10.4, 8.8–12.2) |
| Only Migraine | 337 (14.3, 12.9–15.7) | 117 (10.9, 9.1–12.9) | 220 (17.1, 15.1–19.2) |
| Only TTH | 692 (29.3, 27.5–31.2) | 343 (31.9, 29.1–34.8) | 349 (27.1, 24.7–29.6) |
| Total | 2365 (100)[a] | 1075 (100) | 1290 (100) |

*Note:* This table illustrates the positive and negative screening outcomes for painful temporomandibular disorders (p-TMD), categorised as 'yes' for positive screening and 'no' for negative screening. It displays responses concerning medical diagnoses of migraine and/or tension type headache (TTH): Consultation: 'Have you ever seen a medical professional regarding your headaches?', Migraine: 'Have you ever been diagnosed with migraine by a medical doctor?', TTH: 'Have you ever been diagnosed with TTH by a medical doctor?'. Responses to questions about migraine and TTH diagnoses are indicated, including options for 'None' (no diagnosis), 'Both' (diagnosed with both migraine and TTH), 'Only migraine' (diagnosed with migraine only) and 'Only TTH' (diagnosed with TTH only). 95% Confidence Intervals (CI) are provided.

[a]Missing data fewer than 5 individuals are not disclosed to safeguard privacy and confidentiality and was randomly allocated.

*p*-value $<0.001$), that is, the odds of experiencing p-TMD are increased by 257% for *moderate/severe* PHQ15 scores compared to *none/mild* scores. After adjustment for gender, the positive association between PHQ-15 and p-TMD was slightly attenuated, OR 3.11, 95% CI 2.82–3.44, *p*-value $<0.001$. The analysis revealed that gender significantly modified the association, p (interaction) $=0.006$. The odds of experiencing p-TMD for individuals with *moderate/severe* PHQ-15 scores, compared *to none/mild* scores, were as follows: *men* OR $=4.37$, 95% CI 3.46–5.52, *other* OR $=3.77$, 95% CI 1.57–9.04 and *women* OR $=2.88$, 95% CI 2.58–3.22. Results indicate that psychological distress as well as physical comorbidities are associated with higher odds of p-TMD, both with a smaller effect size for *women* compared to *men*. In the gender group *other*, although the CIs were relatively wide, results suggest a potential association between both psychological distress and physical comorbidities, and p-TMD.

The occurrence of high-impact GCPS scores was: 39.9% (95% CI, 37.9%–41.9%) in individuals with co-occurrence of p-TMD and headache, 6.3% (95% CI, 4.3%–8.7%) in p-TMD individuals without headaches, and 16.2% (95% CI, 15.2%–17.3%) in individuals reporting headaches but no p-TMD, Table 6. GCPS according to self-reported primary headache diagnosis (other, both migraine and TTH, only migraine, and only TTH), among individuals who screened positive for p-TMD, is displayed in Table S3. Data show slight variations in pain impact and intensity across different primary headaches in individuals with p-TMD, with those that reported both migraine and TTH showing the highest burden of pain severity and impact.

### 3.1 | Sensitivity Analysis

By performing inverse probability weighting (IPW) for both selection levels, we aimed to mitigate biases and ensure that our respondents were comparable to the main cohort. The results of the IPW analysis indicated that the prevalence of p-TMD decreased by 2% point. This decrease was deemed not relevant.

## 4 | Discussion

The main findings of this study indicate a high prevalence of p-TMD in young adults, which is in contrast to existing literature.

**TABLE 3** | Gender distribution according to medical diagnosis of migraine and/or tension-type headache (TTH).

| | | Gender distribution | | |
|---|---|---|---|---|
| | **Total** | **Men** | **Women** | **Other** |
| | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** |
| Consultation | | | | |
| Yes | 2365 (32, 30.9–33.1) | 379 (20.2, 18.4–22.1) | 1957 (36, 34.7–37.3) | 29 (38.7, 27.6–50.6) |
| No | 5024 (68, 66.9–69) | 1499 (79.8, 77.9–81.6) | 3479 (64, 62.7–65.3) | 46 (61.3, 49.4–72.4) |
| Total | 7389 (100)[a] | 1878 (100) | 5436 (100) | 75 (100) |
| Migraine | | | | |
| Yes | 622 (26.3, 24.5–28.1) | 105 (27.4, 23–32.2) | 509 (26, 24.1–28) | 8 (27.6, 12.7–47.2) |
| No | 1743 (73.7, 71.9–75.5) | 275 (72.6, 67.8–77) | 1447 (74, 71.9–75.9) | 21 (72.4, 52.8–87.3) |
| Total | 2365 (100)[a] | 380 (100) | 1957 (100) | 29 (100) |
| TTH | | | | |
| Yes | 977 (41.3, 39.3–43.3) | 107 (28.2, 23.7–33.1) | 860 (43.9, 41.7–46.1) | 10 (34.5, 17.9–54.3) |
| No | 1388 (58.7, 56.7–60.7) | 272 (71.8, 66.9–76.2) | 1097 (56.1, 53.8–58.3) | 19 (65.5, 45.7–82.1) |
| Total | 2365 (100)[a] | 379 (100) | 1957 (100) | 29 (100) |
| Migraine/TTH | | | | |
| None | 1052 (44.4, 42.4–46.5) | 201 (53, 47.9–58.1) | 836 (42.7, 40.5–44.9) | 15 (51.7, 32.5–70.5) |
| Both | 284 (12, 10.7–13.4) | 33 (8.7, 6.1–12) | 247 (12.6, 11.2–14.2) | ≤ 5[b] |
| Only Migraine | 337 (14.3, 12.9–15.7) | 71 (18.7, 14.9–23) | 262 (13.4, 11.9–15) | ≤ 5[b] |
| Only TTH | 692 (29.3, 27.5–31.2) | 74 (19.5, 15.6–23.9) | 612 (31.3, 29.2–33.4) | 6 (20.7, 8–39.7) |
| Total | 2365 (100)[a] | 379 (100) | 1957 (100) | 29 (100) |

*Note:* This table illustrates the gender distribution (Men, Women, Other) according to responses concerning medical diagnoses of migraine and/or tension type headache (TTH): Consultation: 'Have you ever seen a medical professional regarding your headaches?', Migraine: 'Have you ever been diagnosed with migraine by a medical doctor?', TTH: 'Have you ever been diagnosed with TTH by a medical doctor?'. Responses to questions about migraine and TTH diagnoses are indicated, including options for 'None' (no diagnosis), 'Both' (diagnosed with both migraine and TTH), 'Only migraine' (diagnosed with migraine only) and 'Only TTH' (diagnosed with TTH only). 95% Confidence Intervals (CI) are provided.
[a]Missing data fewer than 5 individuals are not disclosed to safeguard privacy and confidentiality and was randomly allocated.
[b]Due to the limited number of individuals (less than 5), publication of these specific data is not permitted to ensure privacy and confidentiality.

**TABLE 4** | Co-occurrence of painful TMD and headache in the total study population.

| | | Co-occurrence of p-TMD and headache | | |
|---|---|---|---|---|
| | **Total** | **Men** | **Women** | **Other** |
| | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** |
| p-TMD: yes/Headache: yes | 2518 (21.8, 21.1–22.6) | 442 (11.2, 10.2–12.2) | 2043 (27.3, 26.3–28.4) | 33 (33.3, 24.2–43.5) |
| p-TMD: yes/Headache: no | 556 (4.8, 4.4–5.2) | 222 (5.6, 4.9–6.4) | 327 (4.4, 3.9–4.9) | 7 (7.1, 2.9–14) |
| p-TMD: no/Headache: yes | 4870 (42.3, 41.3–43.2) | 1436 (36.3, 34.8–37.8) | 3392 (45.4, 44.3–46.5) | 42 (42.4, 32.5–52.8) |
| p-TMD: no/Headache: no | 3581 (31.1, 30.2–31.9) | 1856 (46.9, 45.3–48.5) | 1708 (22.9, 21.9–23.8) | 17 (17.2, 10.3–26.1) |
| TOTAL | 11,525 (100) | 3956 (100) | 7470 (100) | 99 (100) |

*Note:* Headache: yes, ≥ 1 day of headache per month; Headache: no, < 1 day of headache per month; p-TMD: *yes*–positive screening for p-TMD; p-TMD: *no*–negative screening for p-TMD. Proportion (%) and 95% Confidence Intervals (CI).
Abbreviation: p-TMD, painful temporomandibular disorders.

This study included young adults across three different gender categories—*men*, *women* and *other*—constituting the first reported prevalence of p-TMD in gender-diverse individuals. Additionally, the correlation between p-TMD and PHQ-4 demonstrated gender-specific variations, with *men*, *women* and *other* exhibiting diverse levels of association. Lastly, it was observed that TTH more commonly coexisted with p-TMD compared to migraine.

**TABLE 5** | Patient health questionnaire 15 (PHQ-15) and the patient health questionnaire 4 (PHQ-4).

| | Painful TMD screening | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | p-TMD: yes | | | | p-TMD: no | | | |
| | Women | Men | Other | Total | Women | Men | Other | Total |
| | *n* (%, 95% CI) | *n* (%, 95% CI) | *n* (%, 95% CI) | *n* (%, 95% CI) | *n* (%, 95% CI) | *n* (%, 95% CI) | *n* (%, 95% CI) | *n* (%, 95% CI) |
| PHQ-15 | | | | | | | | |
| Moderate/ Severe | 1545 (70.7, 68.7–72.6) | 190 (30.6, 29–32.2) | 25 (67.6, 50.2–82) | 1760 (61.9, 60.1–63.7) | 2008 (41.9, 40.5–43.3) | 291 (9, 8.1–10.1) | 23 (41.1, 28.1–55) | 2322 (28.8, 27.8–29.8) |
| None/Mild | 641 (29.3, 27.4–31.2) | 431 (69.4, 67.8–71) | 12 (32.4, 18–49.8) | 1084 (38.1, 36.3–39.9) | 2783 (58.1, 56.7–59.5) | 2933 (91, 89.9–91.9) | 33 (58.9, 45–71.9) | 5749 (71.2, 70.2–72.2) |
| Total | 2186 (100) | 621 (100) | 37 (100) | 2844 (100) | 4791 (100) | 3224 (100) | 56 (100) | 8071 (100) |
| PHQ-4 | | | | | | | | |
| Moderate/ Severe | 623 (28.5, 26.6–30.5) | 133 (21.4,18.3–24.9) | 25 (67.5, 50.2–81.9) | 781 (27.5, 25.9–29.2) | 789 (16.5, 15.4–17.6) | 273 (8.5, 7.5–9.5) | 26 (46.4, 32.9–60.2) | 1088 (13.5, 12.8–14.3) |
| None/Mild | 1560, (71.5, 69.5–73.3) | 487 (78.5,75.1–81.7) | 12 (32.4, 18–49.8) | 2059 (72.5, 70.8–74.1) | 3988 (83.5, 82.4–84.5) | 2942 (91.5, 90.5–92.4) | 30 (53.6, 34.3–71.6) | 6960 (86.5, 85.7–87.2) |
| Total | 2183 (100) | 620 (100) | 37 (100) | 2840 (100) | 4777 (100) | 3215 (100) | 56 (100) | 8048 (100) |

*Note:* Prevalence of moderate/severe and none/mild scores on the PHQ-15 and the PHQ-4 according to gender and stratified on positive (p-TMD yes) and negative (p-TMD-no) screening for painful TMD p-TMD. Proportion (%) and 95% confidence intervals (CI).

**TABLE 6** | Graded Chronic Pain Scale (GCPS) according to overlap of headache and painful TMD screening status.

| | | Combined status: painful TMD screening and headaches | | |
|---|---|---|---|---|
| | **Total** | **p-TMD: yes, headache: yes** | **p-TMD: yes, headache: no** | **p-TMD: no, headache: yes** |
| | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** | ***n* (%, 95% CI)** |
| GCPS | | | | |
| 0-IIa Low-impact | 5699 (76.9, 75.9–77.9) | 1417 (60.1, 58.1–62.1) | 479 (93.7, 91.2–95.7) | 3803 (83.7, 82.6–84.8) |
| IIb-IV High-impact | 1711 (23.1, 22.1–24.1) | 942 (39.9, 37.9–41.9) | 32 (6.3, 4.3–8.7) | 737 (16.2, 15.2–17.3) |
| Total | 7410 (100) | 2359 (100) | 511 (100) | 4540 (100) |
| CPI | | | | |
| None | 364 (4.7, 4.3–5.2) | 8 (0.3, 0.3–0.4) | 22 (4.1, 2.6–6.1) | 334 (7.1, 6.3–7.9) |
| Low (≤ 50) | 6100 (79.2, 78.3–80.1) | 1715 (69.9, 68.0–71.7) | 474 (88.1, 85.1–90.7) | 3911 (83.1, 81.9–84.1) |
| High (> 50) | 1236 (16.1, 15.3–16.9) | 732 (29.8, 28.0–31.7) | 42 (7.8, 5.7–10.4) | 462 (9.8, 8.9–10.7) |
| Total | 7700 (100) | 2455 (100) | 538 (100) | 4707 (100) |
| 6-month frequency | | | | |
| 0 to 6 days | 1884 (23.8, 22.9–24.8) | 282 (11.2, 10.0–12.5) | 275 (49.6, 45.4–53.8) | 1327 (27.4, 26.1–28.7) |
| 7 to 14 days | 1924 (24.3, 23.4–25-3) | 415 (16.6, 15.1–18.1) | 121 (21.8, 18.5–25.5) | 1388 (28.6, 27.4–29.9) |
| 15 to 30 days | 2070 (26.2, 25.2–27.2) | 697 (27.8, 26–29.6) | 87 (15.7, 12.8–19) | 1286 (26.5, 25.3–27.8) |
| ≥ 31 days | 2029 (25.7, 24.7–26.6) | 1114 (44.4, 42.5–46.4) | 71 (12.8, 10.1–15.9) | 844 (17.4, 16.4–18.5) |
| Total | 7907 (100) | 2508 (100) | 554 (100) | 4845 (100) |

*Note:* Headache: yes, ≥ 1 day of headache per month; Headache: no, < 1 day of headache per month; p-TMD: *yes*, positive screening for p-TMD; p-TMD: no, negative screening for painful TMD. The answer to: 'How many days in the last 6 months have you had facial pain?' is presented as *6-month frequency*.
Abbreviations: CI, 95% confidence intervals; CPI, characteristic pain intensity.

The overall prevalence of p-TMD was 26.4%, a figure higher than previously reported in North American and Swedish population-based epidemiological studies (Lipton et al. 1993; Lovgren et al. 2016; Macfarlane et al. 2014). A large North American study with 45,711 individuals aged 18 to 75+ years reported prevalence rates ranging from 0.7% to 12.2% for orofacial pain conditions (Lipton et al. 1993). While Lipton et al. (Lipton et al. 1993) employed a comprehensive interview questionnaire capturing rich qualitative data, the absence of a standardised and validated tool limits sensitivity and specificity, hindering direct comparison with the present results. A Swedish study estimated the prevalence of frequent pain in the temple, face and jaw joint to be 3.4%, and prevalence of frequent pain during jaw movement to be 1.6% (Lovgren et al. 2016). In their study involving 137,718 screened adults, a subsample of 24,794 aged 20 to 29 years, that is, comparable to the present study population, reported average prevalence rates for males and females: jaw pain (2% for males, 7% for females), pain during jaw movement (2% for males, 3% for females), jaw locking (2% for males, 4% for females), and related symptoms (4.5% for males, 10% for females) (Lovgren et al. 2016). The screening tool used was the 3Q/TMD, validated in relation to the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) but with lower diagnostic sensitivity compared to the TMD pain screener used in the present study (Gonzalez et al. 2011; Lövgren et al. 2016). Furthermore, the different temporal assessment between the 3Q/TMD, considering pain 'once a week or more,' and the TMD pain screener's 'pain in the last 30 days' could contribute to the higher observed p-TMD prevalence in our study. Notably, in the Swedish study, 65% of the population aged 20 to 29 responded to the 3Q/TMD as part of routine dental screening (Lovgren et al. 2016). It is plausible that individuals with orofacial pain in Sweden, potentially managed in tertiary care centres as Sweden stands as the sole European nation officially recognising orofacial pain as a specialty, might experience fewer pain episodes or resolution over time, leading to lower reported prevalence. Additionally, temporary absence from routine dental appointments due to specialist consultations in orofacial pain may be speculated to have influenced the reported prevalence rates.

The high prevalence of p-TMD in the present study could be influenced by false positives due to factors such as third molar eruption. The specificity of the TMD pain screener to distinguish between odontogenic and p-TMD is reported to be 0.59 (95% CI: 0.41 to −0.75) (Fonseca Alonso et al. 2017), possibly leading to a higher false positive rate in our sample, particularly given the age range where third molar eruptions commonly occur. Additionally, some participants in the present study may have tested positive for p-TMD due to the coexistence of odontogenic issues and TMD, as non-odontogenic or mixed tooth pain is observed in 12% to 50% of patients seeking care (Linn et al. 2007). However, the 2:1 (women: men) gender distribution in the present study aligns with the norm for p-TMD, with no significant gender disparity in odontogenic pain prevalence. The effectiveness of the 3Q/TMD in differentiating between odontogenic and TMD pain is unknown, and the TMD pain screener's assessment in specialised clinics may overestimate changes in the performance of the screener in larger population studies (Fonseca Alonso et al. 2017).

The present study showed that moderate/severe PHQ-15 scores and moderate/severe PHQ-4 scores were more frequently observed in individuals screening positive for p-TMD compared to those screening negative. Likewise, the OPPERA studies have consistently reported that patients with p-TMD exhibit higher levels of anxiety, depression and a greater burden of comorbid physical conditions when compared with healthy individuals (Fillingim et al. 2013; Slade et al. 2016). Also, in accordance with our results, sex disparities have been consistent across studies, with females demonstrating a higher prevalence of p-TMD (Häggman-Henrikson et al. 2020; Lovgren et al. 2016). However, the role of being female as a risk factor for first-onset p-TMD remains debated. The OPPERA cohort observed only a marginally higher incidence in females (Slade et al. 2013a), while Swedish research found that females are twice as likely as males to experience both first-onset and persistent p-TMD (Häggman-Henrikson et al. 2020). Literature is consistent in that both psychosocial distress and physical comorbidities are crucial to understanding the complex nature of p-TMD (Slade et al. 2013b). The burden of some of these risk factors has been reported to be particularly pronounced in females (Iodice et al. 2024; Phillips et al. 2001). Our cross-sectional study suggests that when moderate/severe levels of psychosocial distress and physical comorbidities are present, the impact on the occurrence of p-TMD may be higher for men compared to women. Additionally, the present study showed that individuals in the gender category *other* exhibited higher PHQ-4 scores, aligning with previous research on elevated mental health risks in gender diverse individuals (Valentine and Shipherd 2018).

Our post-COVID-19 data collection timing may have affected p-TMD prevalence, coinciding with vaccine policy changes and mask mandate removals in Denmark. Pandemic-related stress, depression and disrupted routines may have influenced our results. In Denmark, 18–24 year-olds showed worsening anxiety and depression towards the pandemic's end, unlike other age groups (Vistisen et al. 2022). Although the COVID-19 pandemic may have intensified the decline in psychosocial well-being, this is a trend that predates the pandemic. Psychological conditions, including anxiety and stress, have been increasing in prevalence, particularly among young adults (Twenge et al. 2019). In Denmark, for instance, registry data has shown that individuals born between 2000 and 2009 exhibit the highest incidence rate for any mental disorder, based on analyses across eight birth cohorts (1924–2011) and six three-year calendar periods (2004–2021) (Momen et al. 2025). Thus, the temporal gap between our current study and previous estimates may partly explain the higher prevalence of p-TMD observed in the Danish population.

Study limitations include potential influence from the COVID-19 pandemic psychological impact and selection bias. Pain-affected individuals may have been more likely to participate, possibly inflating p-TMD prevalence. However, the main cohort's higher socio-occupational status compared to the general Danish population might lead to underestimation (Jacobsen et al. 2010).

The high prevalence of TTH (31.9%) compared to migraine (10.9%) in individuals with p-TMD contradicts existing literature. A systematic review and meta-analysis (Yakkaphan et al. 2022) reported an 82.8% prevalence of headache in p-TMD

patients, but our findings indicate a notable difference in the prevalence of diagnosed migraine and TTH within the p-TMD group. While the pooled analysis of data by Yakkaphan et al. (Yakkaphan et al. 2022) showed no significant difference between the two, Franco et al. (Franco et al. 2010) reported that migraine (55.39%) is the most common primary headache in individuals with p-TMD, followed by TTH (30.2%). In the later study (Franco et al. 2010), the use of the Research Diagnostic Criteria for TMD may have led to an overdiagnosis of p-TMD when compared to the present study, which may have been enhanced by the presence of allodynia in migraineurs (Bevilaqua-Grossi et al. 2010).

A more recent nested case–control study (Tchivileva et al. 2017) showed that, at both baseline and follow-up, the number of subjects with overlapping TTH and p-TMD (52%–57.1%) is higher compared to the number of subjects with overlapping migraine and p-TMD (16.1%–8.4%). The authors suggest migraine, but not TTH, as a risk factor for incident TMD. In the general population, the prevalence of migraine is about three times higher in women than in men, and is more likely to affect individuals between the ages of 25 and 55 (Victor et al. 2010). As such, migraine and p-TMD exhibit at least these common traits.

Headache attributed to TMD has been reported to share similarities with TTH, such as tenderness in the pericranial muscles (Exposto et al. 2021). Headache attributed to TMD is described by patients with p-TMD as symptoms linked to the TMD itself. This is a secondary headache according to the ICHD-3 and DC/TMD classifications (International Headache Society 2018; Schiffman et al. 2014) with a prevalence reaching up to 29.3% of patients seeking treatment in a tertiary care centre (Vivaldi et al. 2018). It can be related to TMJ arthralgia, but it is more often observed in those with myogenous TMDs, predominantly myofascial pain with referral, rather than localised myalgia (Tchivileva et al. 2021). The musculoskeletal tenderness observed in p-TMD, coupled with pericranial tenderness, suggests a closer pathophysiological connection between p-TMD and TTH than with migraine. While definitive evidence of a clear link between p-TMD and a specific primary headache is lacking, there is a conceivable mutual influence. Addressing both p-TMD and headache conditions simultaneously holds potential for enhancing patient outcomes and satisfaction (Goncalves et al. 2013).

This study assessed the prevalence of TTH and migraine based on self-reported medical diagnosis, instead of using validated screening questionnaires. Although this may be considered a limitation, it can also serve as a proxy for diagnoses made through clinical examination and interview, especially since the Danish Reference Programme (Schytz et al. 2020) follows the ICDH-3 (International Headache Society 2018) and has been in use for over two decades. However, we did not determine whether the self-reported medical diagnoses were current or non-active.

In conclusion, this study found 26.4% p-TMD prevalence in young adults, with 31.9% TTH and 10.9% migraine coexistence in p-TMD individuals. The association between p-TMD and psychological distress as well as physical comorbidities was stronger in men than in women.

### Author Contributions

This study was designed by Lene Baad-Hansen (L.B.H.), Cristina Rocha Exposto (C.R.E.) and Bodil Hammer Bech (B.H.B.). Data was primarily collected and analysed by C.R.E. Mojdeh Mansoori (M.M.) contributed to data retrieval. The results were critically examined by all authors. C.R.E. had a primary role in preparing the manuscript, which was edited by L.B.-H., B.H.B. and M.M. All authors have approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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The authors have nothing to report.

### Conflicts of Interest

The authors declare no conflicts of interest.

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**Supporting Information**

Additional supporting information can be found online in the Supporting Information section.