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ORIGINAL

# Pilot validation of a digital tool for predicting the risk of temporomandibular disorders: integration of Delphi and ICONIX

## Validación piloto de una herramienta digital para predecir el riesgo de trastornos temporomandibulares: integración de Delphi e ICONIX

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## ABSTRACT

**Introduction:** temporomandibular disorders (TMD) are prevalent conditions that often remain underdiagnosed due to limited access to standardized tools.
**Objective**: to conduct a preliminary evaluation of the diagnostic performance of a web-based screening application for TMD, developed as a digital health tool aimed at early detection and support clinical decision-making.
**Method**: a cross-sectional pilot study was conducted between March and May 2024 at the Department of Clinical Surgery, School of Stomatology, Benemérita Autonomous University of Puebla (Mexico). A convenience sample of 18 undergraduate students (>18 years) completed a 10-item self-administered web questionnaire, designed using the Delphi method and weighed through the ICONIX modeling approach. Clinical evaluation was performed blinded to the application results, using the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) as the reference standard. Statistical analysis included descriptive statistics, Student's t-test, Cohen's kappa coefficient, and ROC curve analysis.
**Results:** the web application demonstrated promising diagnostic performance, correctly identifying 12 of 13 clinically confirmed TMD cases. Sensitivity was 92,3 %, specificity 60 %, positive predictive value 85,7 %, and overall, diagnostic accuracy 83,3 %. The area under the ROC curve (AUC) was 0,762, with a Youden index of 0,52. Cohen's kappa coefficient was 0,56, indicating a moderate level of agreement between digital classification and clinical diagnosis. No significant differences were observed in mandibular functional variables between groups with and without TMD.
**Conclusions:** this preliminary pilot study suggests that the web-based application is a feasible and moderately accurate tool for syndromic risk stratification of TMD. While the results are encouraging, the small sample size and limited population generalizability highlight the need for future studies with larger and more diverse samples to validate its diagnostic performance.

**Keywords:** Temporomandibular Joint Disorders; Mobile Applications; Diagnostic Self Evaluation; Surveys and Questionnaires; Decision Support Systems Clinical.

**RESUMEN**

**Introducción:** los trastornos temporomandibulares (TTM) son condiciones prevalentes que suelen estar subdiagnosticadas por la falta de acceso a herramientas estandarizadas.**Objetivo:** Realizar una evaluación preliminar del rendimiento diagnóstico de una aplicación web de tamizaje para TTM, desarrollada como herramienta de salud digital orientada a la detección temprana y al apoyo en la toma de decisiones clínicas. **Método:** se llevó a cabo un estudio piloto transversal entre marzo y mayo de 2024 en el Departamento de Cirugía Clínica, Facultad de Estomatología, Benemérita Universidad Autónoma de Puebla (México). Se utilizó una muestra por conveniencia de 18 estudiantes de pregrado (>18 años), quienes completaron un cuestionario web autoadministrado de 10 ítems, diseñado mediante el método Delphi y ponderado a través del enfoque de modelado ICONIX. La evaluación clínica se realizó de manera cegada a los resultados de la aplicación, utilizando como referencia los Criterios Diagnósticos para Trastornos Temporomandibulares (DC/TMD). El análisis estadístico incluyó estadística descriptiva, prueba t de Student, coeficiente kappa de Cohen y análisis de la curva ROC.
**Resultados:** la aplicación web mostró un rendimiento diagnóstico prometedor, identificando correctamente 12 de los 13 casos clínicamente confirmados de TTM. La sensibilidad fue del 92,3 %, la especificidad del 60 %, el valor predictivo positivo del 85,7 % y, en general, la exactitud diagnóstica del 83,3 %. El área bajo la curva ROC (AUC) fue de 0,762, con un índice de Youden de 0,52. El coeficiente kappa de Cohen fue de 0,56, lo que indica un nivel moderado de concordancia entre la clasificación digital y el diagnóstico clínico. No se observaron diferencias significativas en las variables funcionales mandibulares entre los grupos con y sin TTM.
**Conclusiones:** este estudio piloto preliminar sugiere que la aplicación web es una herramienta factible y moderadamente precisa para la estratificación sindrómica del riesgo de TTM. Si bien los resultados son alentadores, el reducido tamaño de la muestra y la limitada generalización a otras poblaciones resaltan la necesidad de realizar estudios futuros con muestras más amplias y diversas para validar su rendimiento diagnóstico.

**Palabras clave:** Trastornos de la Articulación Temporomandibular; Aplicaciones Móviles; Autoevaluación Diagnóstica; Encuestas y Cuestionarios; Sistemas de Apoyo a la Decisión Clínica.

## INTRODUCTION

Temporomandibular disorders (TMD) comprise a heterogeneous group of musculoskeletal and neuromuscular conditions that affect the temporomandibular joint (TMJ), the masticatory muscles, and adjacent structures such as bones, ligaments, and ear.[1,2] These disorders are the most common cause of non-odontogenic chronic oro-facial pain and represent the third leading cause of pain and disability in the field of dentistry.[3] The American Academy of Orofacial Pain emphasizes that TMD significantly impact both the physical health and the psychological and emotional well-being of patients, resulting in negative repercussions on their quality of life and social functioning.[4,5]

Recent studies have estimated that the prevalence of TMD in the general population is approximately 47 % in South America, 33 % in Asia, and 29 % in Europe.[6,7] Although the exact prevalence of clinical signals and symptoms may vary depending on the population and the diagnostic methods employed, it is estimated that between 34 % and 50 % of adults present at least one clinical sign of TMD, such as joint clicking or abnormal movements leading to recurring joint or myofascial pain.[8]

The etiology of TMD is complex and multifactorial, and cannot be attributed to a single cause, but rather to the interaction of multiple factors.[9] These factors are commonly categorized as predisposing, initiating, and perpetuating. Predisposing fac-tors include genetic-biological components, systemic diseases such as rheumatoid arthritis, and psychosocial or emotional stress. Initiating factors involve direct or indirect trauma to the TMJ or cervical regions, while perpetuating factors include para-functional habits such as bruxism, nail-biting, occlusal disharmonies, insomnia, muscle tension, and postural imbalances.[10,11,12]

Pain associated with TMD is a frequent reason for dental consultation; therefore, it is crucial that dental professionals are capable of accurately diagnosing and managing this condition. Identifying individuals at greater risk of developing TMD and recognizing procedures likely to trigger or exacerbate these disorders is essential to pre-vent acute or chronic manifestations.[1,13,14] In this context, self-care plays a pivotal role in the comprehensive management of TMD, either as a standalone strategy or in conjunction with clinical treatments. Its effectiveness largely depends on patient motivation, engagement, and adherence, as well as on the education provided to help patients understand their condition and the expected outcomes.[15]

Self-management of TMD can be promoted through various strategies, including peer support, professional guidance, and educational resources in either digital or printed formats.[15] To maximize its impact, it is essential to actively involve patients, family members, healthcare professionals, and other stakeholders

in the development, review, and evaluation of educational materials and self-care training programs. This collaborative approach not only enhances the effectiveness of self-care interventions but also strengthens the knowledge and competencies of healthcare providers in promoting them.[16,17,18]

For these reasons, the present pilot study aimed to conduct a preliminary evaluation of the diagnostic accuracy and performance of a web-based application designed to estimate the syndromic risk of TMD. This tool was developed by the Department of Clinical Surgery at the School of Stomatology, Benemérita Autonomous University of Puebla (Mexico), and was tested in a clinical population attending its dental care services.

## METHOD

### Design

A descriptive, cross-sectional observational study was conducted between March and May 2024 at the Department of Clinical Surgery of the School of Stomatology, Benemérita Autonomous University of Puebla (Mexico). The study was designed in accordance with the STROBE guidelines for observational research.[19] The protocol was approved by the Ethics Committee of the Autonomous University of Puebla (Approval No. 183, 2024). All participants provided written informed consent prior to inclusion, in compliance with the Declaration of Helsinki.[20]

### Context

TMD are prevalent among young adults and have implications for oral function, quality of life, and academic performance. Despite their clinical relevance, the implementation of standardized diagnostic tools such as the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) in educational or primary care settings remains limited. This is often due to time constraints, a lack of trained personnel, or logistical barriers.[21,22,23] These challenges underscore the need to develop and explore the use of digital health strategies, such as online screening applications, to facilitate the early identification of TMD and support clinical decision-making.

### Participants

The study sample consisted of 18 undergraduate students from the School of Stomatology who were enrolled between the 4th and 9th semesters at the time of the study. Participants were recruited through non-probability convenience sampling, via internal university campus announcements and institutional email.

All participants signed written informed consent forms prior to inclusion, in accordance with the ethical principles of the Declaration of Helsinki. Eligibility criteria were as follows:

### Inclusion criteria

- Individuals over 18 years of age who voluntarily agreed to participate by signing the informed consent form.

### Exclusion criteria

- Individuals with cognitive impairments prevented them from using a smartphone or computer without assistance.
- Individuals under pharmacological treatment could alter pain perception.
- Participants with incomplete or incorrectly recorded responses in the web application.
- Participants who withdrew before completing the clinical evaluation.

### Clinical Evaluation

The clinical examination was conducted by a trained and calibrated dentist, strictly following the DC/TMD, developed by the International Network for Orofacial Pain and Related Disorders Methodology (INfORM). These criteria are widely recognized as the gold standard for the clinical diagnosis of TMD.[24,25,26] Standard printed forms were used to record clinical findings, including presence and location of pain, pattern and trajectory of mouth opening, lateral and protrusive mandibular movements, joint sounds, and palpation of 20 muscle sites and 4 joint sites. Final clinical diagnosis was established using the DC/TMD decision tree, allowing classification into three diagnostic categories: muscular, articular, or mixed temporomandibular disorders. Additionally, functional mandibular measures were recorded, including comfortable opening, maximum unassisted opening, and maximum assisted opening.

### Web-Based TMD Risk Probability Application

The web application was developed by the Department of Clinical Surgery of the School of Stomatology at the Benemérita Autonomous University of Puebla (Mexico), with the aim of estimating the syndromic risk of temporomandibular disorders (TMD) through a self-administered questionnaire composed of 10 dichotomous (yes/no) items. The items were designed to identify clinically relevant signs and symptoms associated with

TMD, such as joint or muscle pain, mandibular dysfunctions, bruxism, traumatic history, and psycho-emotional factors. The application was officially registered on July 9, 2024, with the National Copyright Institute of Mexico under code 023-2024-070411450500-01 and is available in version 1.2 online through the following portal: http://148.228.3.6:8085/ttm (figure 1).


**Figure 1.** Home Portal of the Web-Based TMD Risk Probability Application

The initial selection of questionnaire items was conducted using the Delphi method, applied over two successive rounds with the participation of seven experts in stomatology and related fields. These experts included clinical specialists, educators, and academics with postgraduate training. Selection criteria focused on clinical relevance, conceptual clarity, and population applicability, thereby ensuring the content validity of the instrument.[27,28]

The refinement phase resulted in a final version of the questionnaire, focused on key dimensions of TMD, such as masticatory pain, functional limitation, joint sounds, morning stiffness, diurnal and nocturnal bruxism, mandibular trauma, and adverse emotional states.[29,30,31,32,33]

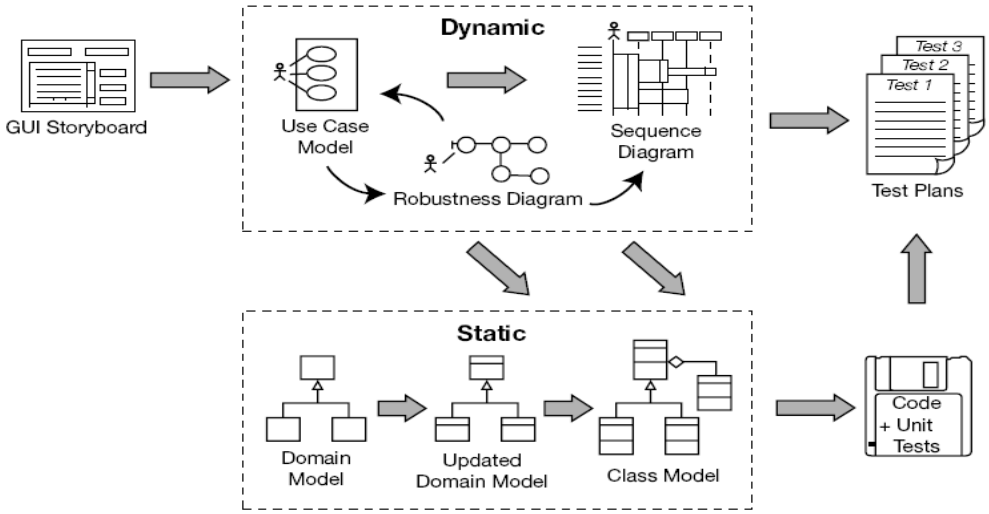


**Figure 2.** ICONIX process diagram Rosenberg[34]

For the design, development, and implementation of the digital version, the ICO-NIX model (Index de COnfiance Numérique eXpert) was employed—a use case–driven software engineering methodology that integrates UML modeling with an iterative and incremental development approach.[34,35] This model enabled a structured definition of the system's functional requirements and facilitated the construction of class, robustness, and sequence diagrams. Operational validation was performed through unit and integration testing with real users (figure 2).

One of the key contributions of the ICONIX model was the integration of a weighted scoring system that combined expert judgment elicited through the Delphi method with recent scientific evidence from clinical studies. Although ICONIX was originally designed to support diagnostic decision-making in expert systems, its core principle, the assignment of differential weights based on the diagnostic relevance of indicators was

adapted in this study for syndromic screening purposes in TMD.

In this context, each of the 10 questionnaire items was assigned a specific weight according to the strength of evidence supporting its association with TMD. These weighted values reflect the relative clinical influence of each item on the final risk classification and were directly implemented in the web application's interpretation algorithm.

**Table 1**. Weighting digital questionnaire items for TMD according to the ICONIX model and expert consensus

| Reference | Questionnaire Item | Weight (%) |
|---|---|---|
| [36] | Have you experienced pain in your jaw, temple, ear, or while opening/closing your mouth during eating in the last month? | 9,9 |
| [31] | Do you feel fatigue when chewing hard or moderately hard food? | 8,3 |
| [37] | Has your jaw ever locked or gotten stuck, making it difficult to open or close your mouth? | 10,9 |
| [38] | Have you felt or heard noises when opening or closing your jaw, or while chewing, in the past month? | 8,0 |
| [39] | Do you grind or clench your teeth at night? | 8,0 |
| [31] | Do you experience stiffness or fatigue in your jaw upon waking? | 8,0 |
| [39] | Do you grind or clench your teeth during the day? | 9,3 |
| [38] | Do you use your teeth incorrectly for tasks like opening bottles, cutting tape, thread, nails, etc.? | 8,6 |
| [40] | Have you received any blows to the jaw or chin? | 8,6 |
| [41] | Have you experienced negative emotional states during the past month? | 8,3 |
| [42] | Sex-based risk adjustment: Male: 75 %; Female: 25 % | 6 |
| [43] | Age-based risk adjustment: 0–20 (10 %); 21–40 (40 %); 41–60 (30 %); 61–80 (15 %); >80 (5 %) | 6 |

**Interpretation Algorithm and Risk Stratification**

The interpretation algorithm classifies the risk of TMD into three levels, based on the weighted sum of affirmative responses:

- Low risk: 0–20 %; Moderate risk: 21–50 %; High risk: ≥51 %

In addition, the model incorporates adjusted demographic factors into the risk calculation, including sex and age, according to the following estimated distributions:

- TMD Risk by Sex; Female: 75 % and Male: 25 %.
- TMD Risk by Age Group; 0–20 years: 10 %; 21–40 years: 40 %; 41–60 years: 30 %; 61–80 years: 15 %; 80 years: 5 %

This mixed-methods approach combining clinical expertise with scientific evidence provides greater robustness to the decision-support system. In this model, symptoms with higher predictive value or syndromic relevance have a proportionally greater impact on the final risk classification. Furthermore, the selection of scientific references for each item ensures that the system is grounded in rigorous clinical studies, involving relevant populations and methodologically sound designs.

**Biases**

To minimize potential sources of bias in this study, several rigorous methodological strategies were implemented. First, the clinical diagnosis was conducted in a blind manner with respect to the results generated by the web application, to prevent observation bias by the examiner. Similarly, participant selection was based on well-defined inclusion and exclusion criteria, which helped reduce selection bias. To control potential confounding variables, validated and standardized instruments were used, including the Diagnostic DC/TMD, and uniform procedures were applied during both clinical and self-reported data collection.

However, it is acknowledged that the small sample size and the specific profile of the study population (undergraduate university students) may limit the external validity of the findings, representing a potential source of bias inherent to cross-sectional observational designs.[44,45]

**Statistical Analysis**

Statistical analyses were conducted using IBM SPSS Statistics version 27 (IBM Corp., Armonk, NY, USA). Descriptive and inferential statistics were used to compare clinical and functional variables between groups classified based on the presence or absence of TMD, as determined both by the DC/TMD and by the risk

classification generated by the web application. Quantitative variables were summarized using means, standard deviations, and 95 % confidence intervals (95 % CI). Group comparisons were performed using the independent-samples Student's t-test, after confirming the assumptions of normality (Shapiro–Wilk test) and homogeneity of variances (Levene's test). A two-tailed significance level of α = 0,05 was adopted. Effect sizes were calculated using Cohen's d and interpreted as small (≥0,10), medium (≥0,30), and large (≥0,50), following standards previously applied in TMD research.[46]

To evaluate the diagnostic performance of the web application compared to the clinical gold standard, a confusion matrix was constructed to estimate the following diagnostic indices: sensitivity, specificity, positive predictive value, negative predictive value (NPV), and overall diagnostic accuracy.[47,48] In addition, Cohen's kappa coefficient was calculated to determine the level of agreement between the two diagnostic classifications, using the following interpretative ranges: poor (< 0), slight (0,00–0,20), fair (0,21–0,40), moderate (0,41–0,60), substantial (0,61–0,80), and almost perfect (0,81–1,00).[49]

A Receiver Operating Characteristic (ROC) curve analysis was also performed to evaluate the discriminative capacity of the percentage-based risk score generated by the web tool, using the clinical diagnosis (positive/negative) as the binary reference variable. The area under the curve (AUC) was used as a global measure of diagnostic performance, interpreted as follows: very poor (0,50–0,59), poor (0,60–0,69), acceptable (0,70–0,79), good (0,80–0,89), and excellent (0,90–1,00).[50] Finally, the optimal cutoff point for the percentage score was determined using Youden's index (sensitivity + specificity − 1), to identify the threshold that best discriminates between individuals with and without a clinical diagnosis of TMD.[51]

These analyses provided a comprehensive assessment of the diagnostic accuracy and performance of the digital tool, in alignment with the primary objective of the study.

## RESULTS

Table 2 presents the descriptive characteristics of the sample, stratified according to the DC/TMD and the classification generated by the web application. Clinical variables related to mandibular function were assessed, including maximum mouth opening, unassisted and assisted opening, as well as the percentage risk score calculated by the application. No statistically significant differences were observed in mandibular functional measures between groups with and without TMD under either diagnostic method. However, the percentage risk scores obtained from both the gold standard, and the web application showed statistically significant differences (p < 0,001), with large effect sizes (d = 2,29 and 2,82, respectively), supporting their discriminative utility in identifying individuals with a higher likelihood of TMD.

**Table 2.** Descriptive characteristics of the sample (n = 18), stratified by DC/TMD and web application classification

| Variable | DC/TMD | | | | Web Application | | | |
|---|---|---|---|---|---|---|---|---|
| | TDM (n = 13) X ± SD (CI 95 %) | No TDM (n = 5) X ± SD (CI 95 %) | p | d | TDM (n =14) X ± SD (CI 95 %) | No TDM (n = 4) X ± SD (CI 95 %) | p | d |
| Maximum mouth opening (mm) | 42,23 ± 6,31 (38,42 – 46,05) | 43,80 ± 5,31 (37,21 – 50,39) | 0,63 | 0,27 | 42,79 ± 6,41 (39,08 - 46,49) | 42,25 ± 4,65 (34,86 – 49,64) | 0,88 | 0,10 |
| Unassisted maximum opening (mm) | 51,54 ± 7,74 (46,86 – 56,22) | 51,60 ± 3,21 (47,62 – 55,58) | 0,98 | 0,01 | 51,21 ± 7,12 (47,11 – 55,32) | 52,75 ± 5,62 (43,81 – 61,69) | 0,70 | 0,24 |
| Assisted maximum opening (mm) | 55 ± 7,77 (50,31 – 59,69) | 53,40 ± 3,05 (49,61 – 57,19) | 0,54 | 0,27 | 54,36 ± 6,92 (50,36 – 58,35) | 55,25 ± 6,95 (44,20 – 66,30) | 0,82 | 0,13 |
| App result (%) | 57,69 ± 13,43 (49,58 – 65,81) | 27,20 ± 13,14 (10,88 – 43,52) | ≤0,001 | 2,29 | 56,86 ± 14,15 (49,27 – 64,45) | 22,50 ± 9,88 (6,77 – 38,23) | ≤0,001 | 2,82 |

TDM: Temporomandibular disorders, DC/TMD: Diagnostic Criteria for Temporomandibular Disorders, X: Mean, SD: Standard deviation, CI: Confidence Interval, p: p-value, d: d Cohen

Table 3 shows the confusion matrix corresponding to the diagnostic performance of the web application compared to the DC/TMD. The tool correctly identified 12 of the 13 positive cases and 3 of the 5 negative cases, recording 2 false positives and 1 false negative, indicating good agreement with the clinical reference standard.

**Table 3.** Diagnostic validation matrix (n = 18)

| Web Application | DC/TMD (Yes) | DC/TMD (No) | Total |
|---|---|---|---|
| TMD (Yes) | 12 | 2 | 14 |
| TMD (No) | 1 | 3 | 4 |
| Total | 13 | 5 | 18 |

TDM: Temporomandibular disorders, DC/TMD: Diagnostic Criteria for Temporomandibular Disorders; App: Application.

Table 4 presents the main diagnostic indices obtained by comparing the classification made by the web application with the DC/TMD for TMD detection. The tool demonstrated high sensitivity (92,31 %), indicating excellent ability to correctly identify subjects with TMD. Specificity was 60 %, suggesting a moderate ability to correctly classify subjects without the condition. In predictive terms, the application achieved a positive predictive value of 85,71 % (95 % CI: 66,97–94,67) and a negative predictive value of 75 % (95 % CI: 28,58–95,74). Overall diagnostic accuracy was 83,33 % (95 % CI: 58,58–96,42), reflecting good overall system performance. The Youden index was 0,52, indicating an adequate discriminative capacity for classifying positive and negative cases. Additionally, the Kappa coefficient was 0,56, representing a moderate level of agreement between the application and the clinical diagnosis, supporting its potential utility as a screening tool in both clinical and community settings.

**Table 4.** Diagnostic performance indicators of the web application compared to the DC/TMD

| Variables | Results (%) | 95 % CI | |
|---|---|---|---|
| | | Lower | Upper |
| Sensitivity | 92,31 | 63,97 | 99,81 |
| Specificity | 60 | 14,66 | 94,73 |
| Positive Predictive Value | 85,71 | 66,97 | 94,67 |
| Negative Predictive Value | 75 | 28,58 | 95,74 |
| Accuracy | 83,33 | 58,58 | 96,42 |
| Variables | | Results | |
| Youden Index | | 0,52 | |
| Kappa coefficient | | 0,56 | |

CI: Confidence Interval, %: percentage.

Table 5 summarizes the results of the ROC curve analysis, conducted to assess the diagnostic performance of the web application in detecting the risk of TMD, using the clinical diagnosis based on the DC/TMD criteria as the reference standard. The AUC was 0,762, with a standard error of 0,145 and a 95 % confidence interval ranging from 0,476 to 1,00. Although the observed AUC value indicates an acceptable discriminative ability, the p-value of 0,094 did not reach statistical significance. The wide confidence interval suggests a high degree of imprecision in the AUC estimate, likely due to the small sample size. Nevertheless, these findings provide preliminary support for the tool's potential utility as a screening strategy, particularly in settings with limited access to specialized care. Further validation in future studies with larger and more representative samples is recommended.

**Table 5**. ROC Curve Analysis of the Web Application for the Detection of TMD Risk

| | AUC | Std. Error | 95 % CI | | p-value |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| Web Application | 0,762 | 0,145 | 0,476 | 1,00 | 0,094 |

## DISCUSSION

This pilot study explored the preliminary diagnostic validity of a web application developed to estimate the syndromic risk of TMD, comparing its results with the clinical diagnosis based on the DC/TMD. The findings indicate that the digital tool demonstrates promising diagnostic performance, evidenced by a sensitivity of 92,3

%, a positive predictive value of 85,7 %, and an AUC of 0,762, within the acceptable range. These results support its potential utility as a screening instrument in clinical and community settings, particularly in environments with limited access to specialized professionals.

The diagnostic value of the tool is enhanced by its mixed algorithmic design, based on the ICONIX approach, which combines scientific evidence and expert clinical judgment. This approach differentiates it from other more generic automated systems, which often lack syndromic adaptation and contextual validation.[34,35] The differential weighting of items, guided by expert consensus and empirical evidence, enables better discrimination of clinically relevant symptoms such as masticatory pain, bruxism, and joint noises, consistent with the main etiopathogenic factors described for TMD.[24,25,26]

The moderate agreement observed between the clinical diagnosis and the application classification (κ = 0,56), although below the optimal level, falls within the expected range for conditions with a high subjective burden and self-assessment methods.[49] Nonetheless, the high sensitivity and overall diagnostic accuracy (83,3 %) suggest that the tool may be useful for initial triage, reducing the risk of false negatives. The Youden index (0,52) identified an optimal cutoff point (≥35 %) with good discriminatory capacity, which could guide future operational versions of the tool.

The young university population in which the tool was applied is particularly relevant, given this group's high prevalence of TMD and increased exposure to associated factors such as stress, bruxism, and academic overload.[52,53,54] However, this characteristic also limits the generalizability of the findings, as results may differ in other populations, such as older adults or individuals with musculoskeletal comorbidities.[1,2,55]

Another important limitation is the small sample size, inherent to pilot studies, which affects the precision of confidence intervals and limits the statistical power to detect subtle differences in clinical parameters. Nevertheless, the effect size analysis (d = 2,82) for the application score reveals a substantial difference between groups, supporting the robustness of the observed findings. Future research is recommended to include larger samples, multicenter designs, and longitudinal approaches to assess the stability of diagnostic performance over time and across diverse clinical contexts.

Beyond its preliminary diagnostic performance, this tool represents an opportunity to incorporate digital health technologies into prevention, education, and early detection strategies in oral health.[56] Its implementation could strengthen telehealth programs, especially in regions with limited specialized dental coverage. Future studies should also evaluate its impact on timely patient referral, cost-effectiveness, and utility as a clinical follow-up instrument in primary care, where limited consultation times, shortage of trained personnel, and logistical barriers hinder timely access.[21,22,23]

Finally, online accessibility, legal registration, and rigorous methodological development strengthen the potential implementation of this tool as a digital health solution. Its inclusion in public health policies could significantly contribute to reducing gaps in early TMD diagnosis and improving the quality of life of affected individuals.

## CONCLUSIONS

The findings of this preliminary pilot study suggest that the web application developed to estimate the syndromic risk of TMD demonstrates promising diagnostic performance, characterized by high sensitivity, adequate overall accuracy, and an area under the AUC indicative of acceptable discriminative ability. Although the agreement with the reference clinical diagnosis was moderate, the tool showed potential utility for initial screening, especially in settings with limited access to specialized professionals. However, the wide confidence interval of the AUC and the lack of strong statistical significance reflect imprecision inherent to the small sample size, warranting cautious interpretation of the results. It is recommended to advance to subsequent validation phases, including larger and more heterogeneous samples, multicenter studies, cross-validation, and evaluation of the temporal reliability of the algorithm. Additionally, exploring its clinical impact, acceptability, cost-effectiveness, and potential use as a follow-up tool in primary care settings would be pertinent. Overall, this digital tool represents an innovative and feasible approach for syndromic screening of TMD, with potential for integration into telehealth strategies, oral health prevention programs, and educational settings focused on self-care.

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## PATENTS

The web application is officially registered with the National Copyright Institute of Mexico under registration code 023-2024-070411450500-01.

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None.

## CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

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