Journal of Dental Sciences 21 (2026) 31–48

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jds.com

Review article

Impact of female hormonal changes throughout life on oral health: A scoping review

Inês Lopes Cardoso [a,b,c,d*], Mayane Fryde [b], Maria Inês Guimarães [a,b,c,e,f], Fernanda Leal [a,b,c]

[a] RISE-Health, Faculty of Health Sciences, Fernando Pessoa University, Fernando Pessoa Teaching and Culture Foundation, Porto, Portugal
[b] Faculty of Health Sciences, Fernando Pessoa University, Fernando Pessoa Teaching and Culture Foundation, Porto, Portugal
[c] FP-I3ID, Institute of Investigation, Innovation and Development, FP-BHS, Biomedical and Health Sciences, University Fernando Pessoa, Porto, Portugal
[d] Escola de Medicina e Ciências Biomédicas (EMCB), Fernando Pessoa Teaching and Culture Foundation, Gondomar, Portugal
[e] INMLCF, I. P., North Delegation - National Institute of Legal Medicine and Forensic Sciences, I. P., Porto, Portugal
[f] CEISUC, Centre of Investigation in Technologies and Centre for Health Studies and Research of the University of Coimbra, Coimbra, Portugal

Received 16 September 2025; Final revision received 25 September 2025
Available online 15 October 2025

KEYWORDS
Women;
Oral health;
Hormonal changes;
Hormonal fluctuations;
Life cycle changes

Abstract This work looks at the impact of female hormonal fluctuations throughout life, during puberty, pregnancy and the menopause, on oral health. These physiological periods, marked by major variations in estrogen and progesterone levels, influence oral health, so the following question was formulated: to what extent do female hormonal fluctuations influence oral health? Through a scoping review of 37 scientific articles selected using a rigorous methodology (in particular using the Rayyan tool), it was possible to highlight clinical manifestations specific to each hormonal stage. In adolescent girls, puberty is frequently accompanied by exacerbated gingivitis, independent of dental plaque. During pregnancy, the increase in hormones leads to increased gingival inflammation and transient tooth mobility. Finally, the menopause is associated with a drop in female sex hormones, which can lead to dry mouth, altered salivary flora and accelerated bone loss, all of which contribute to the worsening of periodontal disease. These results underline the importance of a preventive and personalized approach to oral health care for patients, taking into account the hormonal context. They also

* Corresponding author. Faculty of Health Sciences, Fernando Pessoa University, Rua Carlos da Maia 296, Porto 4200-150, Portugal.
E-mail address: mic@ufp.edu.pt (I. Lopes Cardoso).

https://doi.org/10.1016/j.jds.2025.09.016

highlight the collaboration between dentists, general practitioners and gynecologists, to optimize comprehensive care for women at every stage of their hormonal life.

Introduction

During their lifetime, women undergo multiple physiological changes due to changes in the content of the two main sex hormones, estrogen and progesterone. These hormonal changes occur from puberty through pregnancy to menopause[1–3] and appear to have a strong influence on the oral cavity as well as periodontal tissues. Female sex steroid hormones can cause changes in the response of periodontal tissue to microbial plaque and, consequently, trigger periodontal disease.[4] In this way, hormonal fluctuations that occur during pregnancy, menstruation, as well as the use of hormonal contraceptives can increase tooth mobility, probably due to physicochemical changes in the periodontium.[5–8]

The first menarche appears in women from the average age of 10—12 and involves the first loss of blood (destruction of the blood-borne endometrium). This is the beginning of fertility in women. The menstrual cycle lasts around 28 days and prepares the uterus for the eventual implantation of the embryo. If there is no fertilization, the cycle starts again and so does the bleeding.[9]

The hypothalamus, located in the ventral part of the brain, secretes gonadotrophin-releasing hormone (GnRH), which is responsible for stimulating the anterior pituitary gland to secrete two gonadotrophins. These hormones are follicle-stimulating hormone (FSH) and luteinizing hormone (LH) and regulate the development of ovarian follicles.[9]

The ovarian cycle is divided into two main phases. The follicular phase runs from day 1 to day 14. In this phase, under the effect of FSH, several follicles begin to mature, but only one will become a Graaf follicle ready for ovulation. During this phase, estrogen production gradually increases. Menstruation occurs, on average, during the first 5 days of the cycle, reflecting the renewal of the endometrium (internal uterine tissue). Ovulation occurs around the 14th day. The peak in LH secretion triggers the release of the mature oocyte.[9]

The luteal phase occurs between the 14th and 28th day. After ovulation, the ruptured follicle becomes the corpus luteum, which secretes mainly progesterone and estrogen. These hormones prepare the endometrium for possible embryo implantation.[9]

If fertilization does not occur, the corpus luteum degenerates, which leads to a decrease in estrogen and progesterone levels. This hormonal drop leads to the destruction of the functional endometrium and the onset of menstruation.[9]

The hormonal regulation of the female menstrual cycle is coordinated by the hypothalamic-pituitary-ovarian axis, the synchronization between the pituitary gonadotropin cycle, the ovarian cycle and the ovarian hormone cycle, as well as the cyclical changes in the uterine endometrium.[9]

Pregnancy is a fascinating biological adventure in which the female body is transformed to create and carry life. From the first days after conception, subtle but powerful hormonal signals reorganize the body's physiological priorities. Everything is done to ensure that the embryo can implant and develop and that the mother-to-be is ready to accompany it to birth and beyond. These transformations are carried out almost entirely by the endocrine system, the invisible but omnipresent conductor of the orchestra throughout gestation.[10]

The first hormones on the scene are produced by the corpus luteum, a temporary structure derived from the ovary, which secretes progesterone and estrogen to prepare the uterus to receive the embryo. But very quickly, the future placenta takes over, starting to produce a key hormone, human chorionic gonadotrophin (hCG). It is this hormone that maintains the corpus luteum at the start of pregnancy, marking the beginning of a new hormonal cycle entirely dedicated to pregnancy.[11]

As the weeks go by, the placenta takes the lead in hormonal operations. It releases large quantities of progesterone, which calms uterine contractions and favors immune tolerance, essential for the survival of the fetus. At the same time, estrogen stimulates the growth of the uterus and breasts and increases vascularization to ensure optimum nutrition for the baby. These two hormones increase continuously throughout pregnancy.[12]

But this hormonal dynamic is far from being limited to a simple duet. Placental lactogen (hPL) adapts the mother's metabolism to favor the energy supply of the fetus, sometimes at the cost of progressive insulin resistance. Prolactin prepares the mammary glands for lactation, oxytocin is mobilized for childbirth, while thyroid hormones, cortisol and the renin-angiotensin-aldosterone system complete this orchestration of rare complexity.[13]

Understanding these changes is not only essential for monitoring pregnancy from a medical point of view. It also allows us to better understand the effects these changes can have on other aspects of a woman's health, such as metabolism, mood or even the state of oral health, which is often neglected in prenatal care.

The menopause, defined as the definitive cessation of menstruation, brings with it a series of significant hormonal changes, mainly a reduction in estrogen levels.[14]

These hormonal fluctuations have a significant impact on women's oral health, affecting various aspects of the oral cavity. The reduction in estrogen influences the function of

the salivary glands, leading to a reduction in salivary flow and changes in saliva composition. Reduced salivation and a more acidic oral pH favor the growth of pathogenic bacteria, increasing the risk of periodontal disease. Studies suggest that hormone replacement therapy may have a beneficial effect, reduce the presence of harmful bacteria and promote a more balanced oral microbial environment.[15]

Conditions such as burning mouth syndrome, oral lichen planus and oral candidiasis are more common in postmenopausal women.

Reduced bone density can lead to resorption of the alveolar bone, increasing the risk of periodontitis and tooth loss, making it essential to maintain good oral hygiene and monitor bone health to prevent these complications.

We will analyze the impact of these hormonal fluctuations in more detail later in our discussion.[15]

Materials and methods

A research protocol was drawn up according to the Joanna Briggs Institute (JBI) model,[16–18] which led to the formulation of the following question: What is the relationship between hormonal changes throughout life and oral health in women? Thus, the PCC acronym used is shown in Table 1.

For the final review, the items identified in the reports drawn up for the guidance of systematic reviews and extension of meta-analyses (PRISMA-ScR) were used. This protocol was registered with the OSF (https://osf.io/jv3fm/(accessed 21 March 2025)).

Inclusion and exclusion criteria

Inclusion criteria

Studies evaluating the effect of female sex hormones on oral health. Articles published in English, French, Portuguese or Spanish. Studies using clinical, histological or biochemical methods.

Exclusion criteria

Studies on non-physiological endocrine pathologies (e.g. polycystic ovary syndrome, hypercorticism) or other hormonal diseases not specific to estrogen and progesterone (diabetes, etc.). Studies using animal models or cell cultures. Systematic, bibliographical or narrative reviews. In vitro studies. Survey studies. Studies relating to education, behavior or psychological factors. Studies on non-sex hormones, biomarkers or the microbiome. Studies on oral hygiene or general oral health. Studies on bone condition, pain or the treatments concerned. Studies on the use of contraceptives.

Table 1 PCC (population, concept, context) strategy.

Population	Women
Concept	Oral health
Context	Hormonal changes during lifespan

Search strategy

The search strategy was planned by two reviewers and revised by a third specialized reviewer, considering the Peer Review of Electronic Search Strategies (PRESS) checklist.[19]

In this scoping review, the search will be carried out in the following databases: PubMed, MED-LINE Plus (via EBESCO), LILACS (via BVSalud), CINAHL Plus (via EBSCO host) and Web of Science. The search strategy recommended by the JBI will be implemented.

A preliminary search was carried out in PubMed, MED-LINE Plus (via EBESCO), LILACS (via BVSalud), CINAHL Plus (via EBSCO host) and Web of Science databases to identify the keywords and index terms used in publications on the subject. This enabled the search strategy to be drawn up for each database (Table 2). This search was carried out on 25 February 2025.

The reference lists of all the articles included were reviewed to check for the possibility of including additional articles. After the search, the identified articles were deposited in the ENDNOTE program. The results of the electronic search were exported to Rayyan®,[20] and duplicates eliminated. The software developer is Rayyan Systems Inc. of Cambridge, MA, USA. The AI-driven software was not used to select articles. The Rayyan software was used as a

Table 2 Search strategy for each database.

Database	Articulation of passwords	Number of articles
PubMed	(Female OR women) AND ("oral health" OR "dental health") AND ("hormonal changes" OR "hormonal fluctuations" OR hormones OR estrogens OR "life cycle changes")	516
MEDLINE Plus (via EBSCO host)	(Female OR women) AND ("oral health" OR "dental health") AND ("hormonal changes" OR "hormonal fluctuations" OR hormones OR estrogens OR "life cycle changes")	294
LILACS (via BVSalud)	(Female OR women) AND ("oral health" OR "dental health") AND ("hormonal changes" OR "hormonal fluctuations" OR hormones OR estrogens OR "life cycle changes")	26
CINAHL Plus (via EBSCO host)	(Female OR women) AND ("oral health" OR "dental health") AND ("hormonal changes" OR "hormonal fluctuations" OR hormones OR estrogens OR "life cycle changes")	89
Web of science	(((ALL = (women)) AND ALL = (oral health)) AND ALL = (hormonal changes)) AND ALL = (life cycle changes)	46

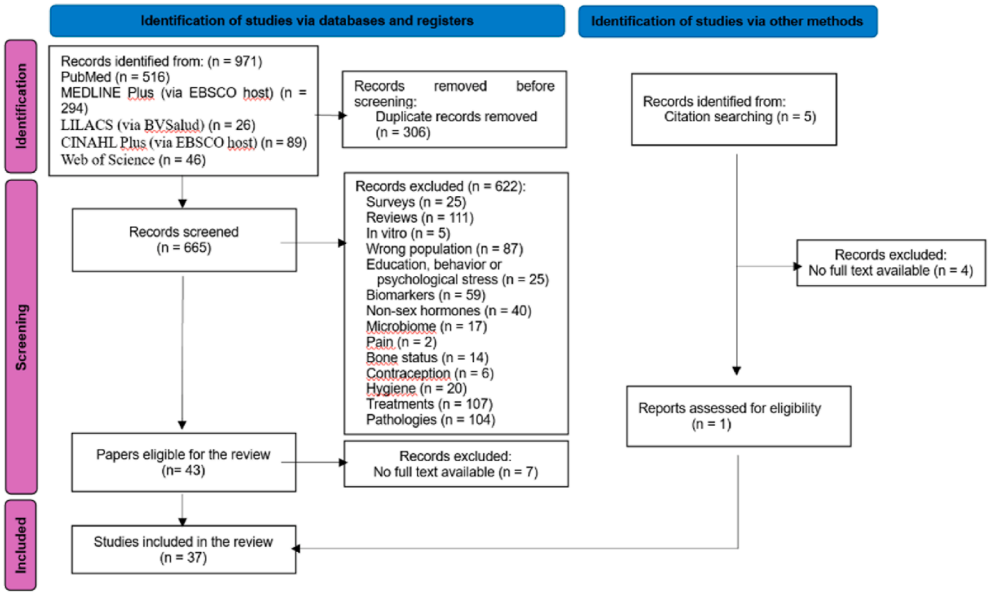

Figure 1 Fluxogram of the article selection process, adapted from PRISMA 2000 flow diagram.[21]

support tool, only to collate all the articles found in the different databases described above and identify duplicates.

Selection, analysis and studies presentation

Two independent reviewers manually removed duplicates, examined study titles and abstracts based on the pre-defined inclusion and exclusion criteria to decide on their inclusion in this scoping review. The full-text articles of potentially eligible studies were independently assessed by the same two reviewers. Doubts and disagreements were discussed with a third reviewer in accordance with the Peer Review of Electronic Search Strategies (PRESS) checklist.[19]

Each article to be included in this review was first analyzed by reading the title and abstract, and then by reading each article in its entirety. This methodology is represented in the Prisma Flowchart (Fig. 1).

After reading the full articles included in this review, data was extracted according to the objectives and research questions of this review. The instrument used for this was the methodology proposed by the Joanna Briggs Institute,[16–18] including the following relevant information: title, author(s), year of publication, country of origin, type of study, objective(s) and results.

In the first phase, filters were applied to the search, resulting in a total of 971 articles. Of these, 306 duplicates were identified and eliminated. The 665 articles obtained were initially screened only by reading the title and abstract, which led to the exclusion of 622, for the reasons shown in Fig. 1.

A total of 43 articles were selected for full reading, 7 of which were eliminated because they were not freely accessible, and 36 publications were selected. In addition, 7 articles were identified through a citation search, 6 of which were rejected because they were not freely accessible. At the end of this selection process, 37 articles were found and included in this scoping review (Fig. 1).

Results

Hormonal impact on oral health of the menstruating woman

Hormonal variations during the menstrual cycle can affect many tissues in the body, including those in the oral cavity. Four articles were included in this topic and their results are described in Table 3.

The study by Balan et al.[22] investigated this issue, looking at possible oral manifestations in healthy young women throughout their menstrual cycle. This work revealed that almost a third of the participants (30 %) reported the appearance of aphthous ulcers, mainly before menstruation. This phenomenon could be linked to hormonal changes, particularly the action of progesterone during the luteal phase, which seems to influence local immunity. A reactivation of cold sores was observed in 5 % of women. This type of lesion can be triggered by hormonal or environmental factors (such as stress or fever). A quarter of the participants also reported mood disturbances or feelings of depression. These symptoms are often associated with a drop in oestrogen before menstruation, which can influence certain neurotransmitters, particularly serotonin. Finally, bleeding gums were observed in 8 % of women, mainly during the premenstrual period. This symptom could be linked to oestradiol peaks and an increase in the gingival inflammatory response. Although the methodology is rigorous, some factors limit the interpretation of the results. In particular, the absence of hormone measurements in blood and saliva makes difficult the establishment of a direct relationship between the observed symptoms and hormone levels. In addition, the frequent stress experienced by students - particularly during exam periods - can lead to mood disorders and influence the appearance of ulcers. The study shows a correlation between the different phases of the menstrual

Table 3 Description of results of selected studies concerning puberty.

Authors[reference]	Type of study	Study objective	Methodology	Results
Balan et al.[22]	Observational study	To study the symptomatic manifestations of the oral mucosa during the menstrual cycle	- Sample: 40 healthy women, followed up for 3 months - Questionnaire analysis and clinical examination in 4 phases of the cycle (menstruation, proliferative, ovulation, secretory).	- 30 % have canker sores. - 25 % have mood swings. - 5 % have cold sores. - 8 % have bleeding gums - These symptoms have been attributed to hormonal variations.
Mishra et al.[23]	Cross-sectional clinical study	To assess tooth mobility during the menstrual cycle using the periotest	- Sample: 50 women - Analysis: measurement of tooth mobility with periotest in 3 phases of the cycle (menstruation, ovulation, pre-menstruation), recording of periodontal indices.	- There was no significant variation in tooth mobility. - An exaggerated gingival response was observed during ovulation and premenstruation.
Khosravisamani et al.[24]	Experimental clinical study	Evaluate the effect of the menstrual cycle on levels of inflammatory cytokines (IL-1β and TNF-α) in crevicular fluid	- Analysis: 27 women with periodontal health. - Analysis: evaluation of GBI, MGI, and cytokines in the 3 phases of the female cycle.	- Significant increase in GBI and MGI during ovulation. - TNF-α varied significantly throughout the cycle. - IL-1β without significant variation.
Aydinyurt et al.[25]	Prospective longitudinal study	Analyze the impact of the menstrual cycle on IL-6, TNF-α levels in gingival fluid and periodontal parameters	- Sample: 45 women - Analysis: ELISA assay (IL-6, TNF-α) at 3 points in the menstrual cycle; clinical periodontal measurements.	- IL-6 and TNF-α increased significantly over the cycle. - No significant changes in PI and PD. - Higher GBI and MGI during ovulation and premenstruation.

GBI - Gingival bleeding index; IL-1β — Interleukin 1β; IL-6 — Interleukin 6; MGI - Modified gingival index; PD - Probing depth; PI — Plaque index; TNF-α — Tumor necrosis factor α.

cycle and certain oral symptoms. These results emphasise the importance of integrating the hormonal dimension into the oral care of women of childbearing age.

Mishra et al.[23] evaluated the association between tooth mobility and hormonal fluctuations that occur throughout the menstrual cycle. In this study, measurements taken were of tooth mobility (corresponding to the horizontal and vertical displacement of the tooth under the application of a force), as well as the plaque index, probing depth and the simplified oral hygiene index (OHIS), at three different times: the luteal/pre-menstrual phase (24—26 days); the follicular/menstrual phase and ovulation. The results obtained showed no significant differences in tooth mobility measurements between the different phases of the cycle. On the other hand, the gingival index reached its highest value in the ovulation phase, decreased in the premenstrual phase and continued to decrease until menstruation. Probing depth and the simplified oral hygiene index showed no relevant changes.

The study by Khosravisamani et al.[24] evaluated the effect of the menstrual cycle on clinical and biological markers of gingival inflammation in young, periodontally healthy women. The study assessed the participants in three phases of the cycle: the start of menstruation (days 1—2), the ovulatory phase (days 12—14) and the premenstrual phase (days 22—24). In each phase, clinical parameters were recorded: the Gingival Bleeding Index (GBI), the Modified Gingival Index (MGI) (a method of visual assessment of gingival inflammation, without probing, based on the observation of clinical signs such as redness, oedema and spontaneous bleeding) and the Oral Hygiene Index (OHI-S) (assessment of tooth cleanliness by quantifying bacterial plaque and tartar on specific tooth surfaces). At the same time, the levels of two pro-inflammatory cytokines - interleukin-1 beta (IL-1β) and tumour necrosis factor alpha (TNF-α) - as well as salivary sex hormones (oestradiol and progesterone) were quantified in saliva and gingival crevicular fluid samples. There was a significant increase in the clinical indexes of gingival inflammation during the cycle. ISG and IGM reached maximum values during the ovulatory phase, suggesting an inflammatory effect associated with increased hormone concentrations, particularly

oestrogen. On the other hand, OHI-S remained stable overall, excluding an important role for dental plaque in the variations observed. There was also a significant increase in TNF-α during the premenstrual phase, while IL-1β showed a non-significant increase. This distinction could be explained by an immune response modulated differently by sex hormones. It is known that progesterone, which peaks at the end of the cycle, increases vascular permeability and modulates the activity of immune cells. In fact, a significant positive correlation was observed between salivary progesterone levels and ISG during ovulation, reinforcing the hypothesis of a direct hormonal link with the gingival inflammatory response. However, some discrepancies with previous studies, particularly regarding IL-1β, emphasise the importance of individual factors (genetics, hygiene, environment) in modulating the periodontal response to the menstrual cycle. Despite its rigorous methodology, the limitation of this study is the relatively small sample size, which limits the generalisability of the results. In addition, although the protocol allowed to control for confounding factors (smoking, medication, oral hygiene), other biological variables that were not analysed, such as stress or the gingival microbiota, could be involved in the regulation of cytokines.

Finally, the study by Aydınyurt et al.[25] evaluates the effects of hormonal variations on periodontal clinical parameters, as well as on the concentration of two key pro-inflammatory cytokines: interleukin-6 (IL-6) and TNF-α, both present in gingival crevicular fluid, at three specific times of the cycle: the menstrual day (days 2—3), the day of ovulation (days 12—14) and the premenstrual phase (days 22—24). This study showed a significant increase in IL-6 and TNF-α levels throughout the menstrual cycle, with maximum values in the premenstrual phase and minimum values in the menstrual period. These variations appear to be closely correlated with hormone levels, with oestradiol and progesterone levels being significantly higher in the premenstrual phase. Clinically, the gingival index (GI) and bleeding on probing (BOP) increased slightly during the ovulatory phase, but without major changes in the plaque index and periodontal disease. The major limitations of this study are the limited duration of follow-up (three cycles) and the relatively small sample size. In fact, the study does not measure the long-term impact of these variations, nor their reversibility.

Hormonal impact on the oral health of pregnant women

Ten articles were included in this topic and their results are described in Table 4.

Regarding periodontal health of pregnant women, the study by Mishra et al.[27] showed a significant increase in tooth mobility in pregnant women, particularly marked in the third trimester. This mobility, measured by the Periotest, is attributed to the combined effect of oestrogen and progesterone on vascular permeability, causing oedema of the periodontal ligament and reducing the ability of the tissues to resist occlusal forces. This increase in mobility was accompanied by an increase in the gingival index, with no significant change in plaque levels, suggesting inflammation of predominantly hormonal origin.[27]

Similarly, the study by Sachelarie et al.[32] confirms that hormone levels, particularly high oestrogen and progesterone, are the main predictors of gingival inflammation during pregnancy. Oral hygiene, although significant, plays a secondary role. On the other hand, vomiting, which is often suspected of aggravating dental erosion, was not statistically correlated with gingival changes, which refocuses attention on endocrine mechanisms.

The inflammatory dimension is also highlighted in the study by Onigbinde et al.,[26] carried out in Nigeria, where most women showed signs of gingivitis or tartar in the third trimester. The Community Periodontal Index (CPI) and OHI-S showed periodontal worsening significantly related to gestational stage and lack of dental visits. On the other hand, age, level of education and parity (number of times a woman has given birth to a viable foetus) showed no statistical association, supporting the idea of a predominantly hormonal effect.

In Latin America, Ruiz Candina et al.[28] studied a sample of 106 pregnant women in Cuba. This study identified a high prevalence of fibroedematous gingivitis (94.4 % of cases of periodontal disease), with an equal distribution between the first and third trimesters. What was surprising was that 20 % of the women had gingivitis despite good oral hygiene, highlighting once again the direct role of hormones in periodontal pathogenesis.

Finally, the Brazilian study by Costa & Silva[29] revealed a high prevalence of tartar, gingival bleeding and periodontal pockets, especially in patients with a high-sugar diet and poor hygiene. However, even among those with good oral hygiene, signs of inflammation were present, suggesting an increased susceptibility of the tissues to inflammation under the effect of gestational hormones. Unlike the other studies, there was little variation between the three trimesters, although there was a slight improvement in the third trimester.

Regarding the oral microbiome and the development of caries in pregnant women, in the study by Yang et al.[33] of 181 low-income pregnant women in the United States, the researchers identified three salivary hormone profiles (low, intermediate, high) based on the detection of six hormones, including progesterone, oestradiol and cortisol. The results showed that participants in the groups with high hormone levels had significantly more decayed teeth, as well as higher concentrations of *Streptococcus mutans* and *Candida albicans* in their saliva. These women also had a higher plaque index and were more likely to come from African-American communities or to smoke.

Similarly, Africa & Turton[2] analysed the oral status of 443 South African pregnant women attending antenatal clinics. The mean index of decayed, missing and filled teeth (DMFT) was 7.18 ± 4.22. Although caries was not significantly correlated with the stage of pregnancy, other pathologies such as pregnancy epulis (8.5 %), oral candidiasis (14.7 %) and tooth mobility (5.9 %) were frequently observed. A statistically significant correlation was found between the number of filled teeth and social factors such as level of education, geographical location and race.

Table 4 Description of results of selected studies concerning pregnancy.

Authors[reference]	Type of study	Study objective	Methodology	Results
Annan & Nuamah[1]	Comparative study	Comparing oral pathologies in pregnant and non-pregnant women.	- Sample: 100 pregnant women and 100 non-pregnant women in Ghana. - Analysis: clinical oral examination.	- Oral changes were more prevalent in pregnant women, linked to physiological hormonal changes.
Onigbinde et al.[26]	Cross-sectional study	To determine periodontal status and associated factors among pregnant women in Nigeria.	- Sample: 415 pregnant women. - Analysis: CPI and OHI-S.	- Gestational age and dental visits significantly influenced periodontal status.
Mishra et al.[27]	Cross-sectional clinical study	To assess tooth mobility during the three trimesters of pregnancy using the periotest.	- Sample: 50 pregnant women. - Analysis: assessments of tooth mobility and periodontal indices in the three trimesters.	- Tooth mobility increased significantly in the third trimester. - Gingivitis was more severe towards the end of pregnancy.
Ruiz Candina et al.[28]	Observational study	To identify the presence of periodontal disease in pregnant women in the first and third trimesters, considering age and oral hygiene.	- Sample: 106 pregnant women. - Analysis: Clinical assessment of periodontal disease and oral hygiene.	- 34 cases of gingivitis and 2 of periodontitis. - Poor oral hygiene was the predominant factor among those affected.
Africa & Turton[2]	Cross-sectional study	Assessing the oral health and treatment needs of pregnant women in KwaZulu-Natal, South Africa.	- Sample: 443 pregnant women. - Analysis: data collection via questionnaire and clinical examination.	- High prevalence of oral lesions, epulides and tooth mobility. - The importance of early screening emphasized.
Costa & Silva[29]	Cross-sectional descriptive study	To analyse the prevalence of periodontal disease and related factors in pregnant women in Natal/RN.	- Sample: 30 pregnant women. - Analysis: CPI and questionnaires on diet and oral hygiene.	- High prevalence of calculus, bleeding gums and enamel lesions. - Poor oral hygiene in general.
Al Agili[30]	Cross-sectional study	Assessing the needs and types of treatments women require before, during and after pregnancy.	- Sample: 1350 postpartum women. - Analysis: Questionnaire to map the treatments received by women (before/during/after pregnancy) and relate them to the respective demographic data.	- Decrease in dental appointments during pregnancy compared to before and after pregnancy. - Pain/caries and gingivitis/periodontitis with no change in prevalence between the groups. - Dental extractions decreased by 5 per cent during pregnancy. - Increased number of dental appointments during pregnancy compared to before and after pregnancy.
Minervini et al.[31]	Cross-sectional case-control study	To explore the relationship between pregnancy and TMD based on the DC/TMD criteria.	- Sample: 32 pregnant women and 35 controls. - Analysis: assessment of pain, jaw function and psychological factors.	- There was no direct association between pregnancy and TMD, but psychological symptoms influenced the results.
Sachelarie et al.[32]	Prospective observational study	To assess the impact of hormones and lifestyle on oral health during pregnancy.	- Sample: 100 pregnant women divided into two groups. - Analysis: Regression analysis of hormonal and lifestyle factors.	- High levels of estrogen and progesterone were associated with stomatognathic changes. - Oral hygiene also had a significant impact on hormonal changes.
Yang et al.[33]	Cross-	To investigate salivary hormone		

(*continued on next page*)

Table 4 (*continued*)

Authors[reference]	Type of study	Study objective	Methodology	Results
	sectional study	levels and their association with caries and cariogenic microorganisms during pregnancy.	- Sample: 181 low-income pregnant women. - Analysis: analysis of unstimulated saliva and oral examinations such as ICDAS and PI.	- High hormone levels associated with higher caries rates and the presence of *S. mutans* and *C. albicans*.

C. albicans - *Candida albicans*; CPI - Community periodontal index; ICDAS - Caries detection and assessment system; PI — Plaque index; *S. mutans* — *Streptococcus mutans*; OHI-S - Simplified oral hygiene index; TMD - Temporomandibular dysfunction.

The study carried out in Ghana by Annan & Nuamah[1] revealed that certain oral pathologies, such as pregnancy epulis (3 %), telangiectasias and aphthous ulcerations, were more frequent in pregnant women than in non-pregnant women. An extreme case of severe gingival haemorrhage was recorded, probably associated with a coagulation disorder (DIC), which occurred at the end of pregnancy.

In a case-control study, Minervini et al.[31] explored the impact of pregnancy on temporomandibular disorders (TMD). Among 32 pregnant and 35 non-pregnant women, pregnant women reported significantly less pain, less parafunctional behaviour (bruxism) and lower scores on the Jaw Functional Limitation Scale (JFLS, an instrument used to assess the degree of functional limitation of the jaw in TMD patients, covering mastication, mobility, communication and overall functional impact). However, the statistical analysis did not confirm a direct and significant influence of pregnancy on all TMD parameters after correction. On the other hand, depression was found to be an important predictor of TMD severity, regardless of pregnancy status.

Finally, the epidemiological study by Al Agili,[30] based on the responses of 1350 postpartum women in Saudi Arabia, revealed a high prevalence of oral and dental problems during pregnancy (cavities, pain, need for extractions). However, only 31 % of women consulted a dentist during pregnancy, and treatments such as extractions, fillings or periodontal treatments were largely avoided or postponed. Only check-ups increased. Most of the care was provided by private clinics, despite the fact that services are free in primary care centres. Women with no insurance or low socio-economic status had the greatest needs and the least access to care.

Hormonal impact on oral health of women on menopause

Twenty articles were included in this topic and their results are described in Table 5.

In the study by Yoshida et al.,[46] the researchers observed a significant difference between the premenopausal, menopausal and postmenopausal groups, particularly regarding unstimulated salivary flow. Postmenopausal women had a significantly lower salivary flow rate than the other groups. Oestradiol levels were positively correlated with salivary flow and negatively associated with depression and salivary amylase activity.

Krupa et al.[3] showed that the duration of the menopause was significantly associated with a reduction in salivary flow. However, tooth loss and OHRQoL did not show a direct relationship with the duration of the menopause.

The study by Ben Aryeh et al.[34] revealed a high prevalence of oral disorders, such as xerostomia, in postmenopausal women. The study also revealed a strong correlation between systemic menopausal symptoms (such as hot flushes) and oral complaints.

Regarding the periodontal health of menopausal women, the study by Deepa & Jain[43] found a high prevalence of periodontitis in postmenopausal women, with an average plaque index of 1.99 and a gingival index of 1.74. It was observed that women with a longer duration of menopause had an increased risk of developing destructive periodontal disease (11 % of participants were completely edentulous). The study by Takahashi et al.[41] revealed a significant negative correlation between the loss of clinical insertion (LA) and the BMD of the lumbar vertebrae and femur. This relationship suggests that systemic bone density loss may be associated with more severe periodontal disease in postmenopausal women.

The microbiological analysis carried out by Hernández-Vigueras et al.[45] showed the presence of *Tannerella forsythia* and *Campylobacter rectus* in 100 % of the samples, while *Fusobacterium nucleatum* and *Porphyromonas gingivalis* were present in 98.7 % of the cases. However, no significant relationship was found between the presence of these pathogens and osteoporosis, although a link between osteoporosis and tooth loss was observed.

Kim et al.[7] showed that women with low BMD had significantly fewer teeth, with a particular link between the duration of menopause and tooth loss. Physiological factors, such as the age of first childbirth and the duration of female hormone use, also showed an influence on tooth loss. Furthermore, Makker et al.[40] found that mandibular BMD was significantly correlated with femoral BMD and biomarkers of bone renewal, namely ionised calcium and osteocalcin, in postmenopausal women. The presence of specific biomarkers in the blood was also associated with an increased risk of mandibular bone loss, with a significant correlation between mandibular BMD and the number of remaining teeth.

Lastly, the results of Pilgram et al.[36] showed that alveolar bone height was moderately correlated with probing insertion level. However, longitudinal changes in bone height and insertion level did not show a significant

Table 5 Description of results of selected studies concerning menopause.

Authors[reference]	Type of study	Study objective	Methodology	Results
Ben Aryeh et al.[34]	Observational study	To explore the relationship between the oral and systemic symptoms of menopause and the oral health/salivary composition/salivary rate of menopausal women before HRT.	- Sample: 154 menopausal women divided into 2 groups (group A - 58 women with no systemic disease or treatment; group B - 96 women with diseases and medications) - Analysis: questionnaire on health and systemic symptoms, intraoral examinations, salivary analysis with measurement of salivary flow and composition (IgA and total protein).	- OR (statistical measure used to estimate the strength of the association between two events - OR = 1: no association/OR > 1: exposure is associated with an increased risk/OR < 1: exposure is associated with a reduced risk) of 8.03 in Group A and 4.08 in Group B for the association between oral discomfort and climacteric symptoms associated with the menopause. - Saliva flow and composition did not change much between the 2 groups. - Total salivary protein and IgA much higher in Group B, probably due to sympathetic activation and psychological stress.
Hakeberg et al.[35]	Cross-sectional epidemiological study	To investigate the prevalence of BMS symptoms and associated factors in Swedish women.	- Sample: 1017 women. - Analysis: questionnaire, medical and dental history.	- 4.6 % of women with BMS. - Positive association between medication, dry mouth and headache and BMS.
Pilgram et al.[36]	Longitudinal study	Exploring the relationship between radiographic alveolar bone height and clinical attachment level in healthy postmenopausal women.	- Sample: 81 women. - Analysis: clinical and radiographic measurements repeated annually for 3 years.	- Strong correlations between measurements of probe insertion height and radiographic bone height. - No relationship between longitudinal changes in alveolar bone height and probe insertion level.
López-Marcos et al.[37]	Observational study	Verify the effectiveness of HRT on the patient's periodontal health.	- Sample: 210 menopausal women aged between 40 and 58, divided into 2 groups (1 group under HRT and the other not). - Analysis: data collection on gingival recessions, pain, mobility and gynecological and odonto-stomatological protocol.	- Better results in the HRT group with regard to pain, mobility, probing depth (distance between the gingival margin and the bottom of the periodontal sulcus) and periodontal pockets (when the probing depth is greater than 3, this is a pathological periodontal pocket). - No significant improvement in gingival recessions in the HRT group.
Tarkkila et al.[38]	Coorte study	Verify the effectiveness of HRT at a systemic and oral level based on different criteria.	- Sample: 400 perimenopausal or recently menopausal women (200 treated with HRT and 200 without HRT). - Analysis: 2 years of oral and periodontal health monitoring - orthopantomography to measure bone bases, measurement of stimulated and unstimulated saliva, WHO criteria (periodontal health	- No difference was observed between the two groups - More dental fillings and dental appointments were recorded in the HRT group, which may suggest greater vigilance in oral health.

(*continued on next page*)

Table 5 (*continued*)

Authors[reference]	Type of study	Study objective	Methodology	Results
			assessment criteria (WHO), the higher the stage of development of periodontal disease); questionnaire on systemic health, medications and oral habits.	
Tarkkila et al.[39]	Coorte study	Verify the effectiveness of HRT-based on bacteriological studies.	- Sample: 135 women aged between 50 and 58. - Analysis: plaque sample - PCR evaluation of *P. gingivalis*, *P. intermedia* and *T. forsythia* (very common bacteria in cases of periodontitis).	- Among women with HRT and with deep periodontal pockets ($\geq$4 mm or $\geq$ 6 mm), there was a reduction in the pathogenic bacteria *P. gingivalis*, *P. intermedia* and *T. forsythia*. This decrease was not observed in the group of women without HRT. - The main explanation for the presence of microorganisms was the depth of the periodontal pockets, regardless of the use of HRT.
Makker et al.[40]	Cross-sectional study	To assess the relationship between bone remodeling markers, mandibular and systemic BMD in Indian women.	- Sample: 371 women. - Analysis: assessment of mandibular and systemic bone density by DXA, and biochemical markers (serum ionized calcium, bone-specific alkaline phosphatase, osteocalcin and total urine pyridinoline).	- Several biomarkers were associated with mandibular BMD. - Significant association between studied biomarkers and bone density.
Takahashi et al.[41]	Cross-sectional study	To assess the relationship between loss of bone insertion and bone density in the lumbar- of postmenopausal women.	- Sample: 347 women aged between 55 and 74. - Analysis: Measurement of insertion level with a periodontal probe (on teeth 16, 17, 26, 27, 31, 36, 37, 46 and 47) and bone density of the femur and lower back with DXA; statistical analysis to correlate the two measurements.	- Significant negative correlation between periodontal disease (measured by clinical attachment loss) and bone mineral density of the lumbar spine and femur. - Women with greater periodontal attachment loss had lower bone density.
Mahesh et al.[42]	Comparative clinical study	Evaluate the impact of menopause and HRT on saliva flow, pH and buffering capacity.	- Sample: 60 women divided into 3 groups (control group with 20 premenopausal women, group with 20 postmenopausal women and group with 20 menopausal women on HRT). - Analysis: saliva stimulation with chewing paste; salivary flow measurement; pH measurement; saliva buffering capacity assessed with Saliva-Check Buffer kit (GC Corporation). - Statistical analysis of the data: chi-square test, Fisher's exact test and ANOVA.	- Decreased salivary flow and pH in menopausal women compared to menstruating women. - Women on HRT with a slight improvement in salivary flow and pH compared to the second group. - Better buffering effect in menopausal women than in the control group.
Kim et al.[7]	Cross-sectional	Analyzing physiological factors	- Sample: 3992 women.	

Table 5 (*continued*)

Authors[reference]	Type of study	Study objective	Methodology	Results
	study	associated with bone density and tooth loss in postmenopausal Korean women.	- Analysis: bone density, number of teeth and reproductive factors.	- Low BMD and higher number of pregnancies associated with greater tooth loss.
Deepa & Jain[43]	Cross-sectional observational study	Assessing periodontal health in postmenopausal women in the Meerut region.	- Sample: 99 postmenopausal women. - Analysis: measurement of periodontal status using the PI, GI, BOP, pocket probing depth and Russell's periodontal index (based on gingival inflammation, periodontal pockets and clinical attachment loss).	- PI-s: 1.99; GI-s: 1.74; BOP: 52.85 %; and mean Russell periodontal index: 4.34. - Eleven patients had early-stage destructive periodontal disease, 34 had established destructive periodontal disease and 30 had end-stage periodontal disease. - These data suggest that postmenopausal women are at risk of developing destructive periodontal disease if they do not follow proper oral hygiene practices.
Han et al.[44]	Cross-sectional study	To assess the relationship between the number of natural teeth in the mouth and the use of HRT in the Korean population.	- Sample: 4869 menopausal women. - Analysis: recording the number of remaining teeth (without taking wisdom teeth into account) and tooth brushing schedule.	- Women undergoing HRT have more natural teeth on average than untreated women.
Hernández-Vigueras et al.[45]	Cross-sectional study	Detect and quantify the most abundant pathogen in the development of periodontitis in menopausal women.	- Sample: 76 menopausal women. - Analysis: PCR quantification of *F. nucleatum*, *A. actinomycetemcomitan*, *P. gingivalis*, *C. rectus* and *T. forsythia*; statistical analysis of the data.	- Periodontitis detected in 77 per cent of women with osteoporosis/osteopenia. - Periodontitis associated with bone loss. - Periodontitis associated with the presence of *F. nucleatum* and *P. gingivalis*. - T. forsythia and C. rectus detected in 100 % samples, F. nucleatum and P. gingivalis in 98.7 % and A. actinomycetemcomitan in 73.7 %.
Yoshida et al.[46]	Analytical cross-sectional observational study	Exploring changes in the oral and systemic health of menopausal women and the relationship between hormonal and mental changes.	- Sample: 97 women aged 40—59 divided into 3 groups (pre-, post- and menopausal women who are dental hygienists). - Analysis: questionnaire to assess general and mental health; measurement of serum 17β-estradiol, salivary flow, α-amylase, SIgA and taste sensitivity.	- Significant difference between the three groups in depression scores, serum 17β-estradiol levels and unstimulated salivary flow. - Significant difference between the groups in the Simplified Menopause Index, the Short-Form 36-Item Health Survey, the General Oral Health Assessment Index, salivary α-amylase activity, salivary SIgA concentration and taste sensitivity threshold. - Level of 17β-estradiol positively correlated with unstimulated salivary flow,

(*continued on next page*)

Table 5 (*continued*)

Authors[reference]	Type of study	Study objective	Methodology	Results
				indicating that higher levels of estradiol favor better saliva production. - 17β-estradiol level with a negative correlation with depression scores and salivary α-amylase activity, suggesting that lower estradiol levels are associated with more depressive symptoms and greater biological stress. - Decreased 17β-estradiol can lead to reduced salivary flow and consequently contribute to oral health problems in postmenopausal women.
Ahn & Lee[47]	Cross-sectional observational study	Evaluate the relationship between HRT and periodontal disease in post-menopausal women.	- Sample: 5482 women divided into two groups (1035 women with HRT and 4447 women not treated with HRT). - Analysis: chi-squared test to assess relationships between variables and a multinomial logistic regression to analyze the effect of HRT on periodontal disease, adjusting for various covariates (age, education, income, BMI, age at menopause, alcohol consumption, smoking, visits to the dentist, oral hygiene and brushing frequency); periodontal health measured using the CPITN index (0 = healthy, 1 −2 = gingivitis, 3 −4 = periodontitis) according to WHO criteria.	- HRT associated with reduced risk of periodontal disease, especially in older women with early menopause or poor oral hygiene. - Importance of integrating HRT, regular dental care and good oral hygiene into health policies for menopausal women.
Lee et al.[48]	Cross-sectional study	Analyzing the relationship between HRT and periodontal disease in postmenopausal women.	- Sample: Korean national data. - Analysis: PSM and logistic regression applied to control bias.	- HRT associated with lower risk of periodontitis, especially in women with early menopause.
Lončar-Brzak et al.[49]	Pilot case-control study	Investigating salivary hormones and quality of life in patients with BMS.	- Sample: 40 women. - Analysis: collection of saliva for hormone dosage and application of questionnaires (OHIP-14).	- Lower salivary estradiol levels in BMS patients. - No association between low estradiol levels and questionnaire results.
Wang et al.[50]	Case-control study	Evaluating the impact of HRT on xerostomia in postmenopausal women.	- Sample: 60 women. - Analysis: determination of salivary estradiol levels before and after HRT; application of a questionnaire.	- Significant improvement in xerostomia and increase in salivary estradiol levels after HRT.
Ozasa et al.[51]	Observational case-control study	Analyzing somatosensory changes in women with BMS at different stages of the menopause.	- Sample: 36 patients with BSS and 42 controls. - Analysis: quantitative sensory tests on the tongue.	- Late postmenopause associated with increased thermal sensitivity. - Hormonal changes affect trigeminal function.
Krupa et al.[3]	Analytical cross-	To analyze changes in salivary		

Table 5 (*continued*)

Authors[reference]	Type of study	Study objective	Methodology	Results
	sectional study	flow, tooth loss and oral health- in relation to quality of life as the duration of menopause increases.	Sample: 327 women divided- into 3 groups (depending on the duration of the menopause). - Analysis: measurement of salivary flow, number of missing teeth, OHRQoL (a subjective measure that assesses how problems in the mouth, such as pain, difficulty eating, speaking or smiling, negatively affect the person's physical, psychological and social well-being in their daily life, taking into account sociodemographic characteristics and oral hygiene).	Strong association between duration of menopause and salivary flow. - Non-significant association between duration of menopause and tooth loss and OHRQoL.

A. actinomycetemcomitan - Aggregatibacter actinomycetemcomitan; ANOVA - analysis of variance; BMD - Bone mineral density; BMS — Burning mouth syndrome; BOP - bleeding on probing; *C. rectus - Campylobacter rectus*; DXA - dual beam X-ray absorptiometry; *F. nucleatum - Fusobacterium nucleatum*; GI-s — mean gingival index; HRT — Hormone replacement therapy; OHRQoL - Oral health related quality of life; PCR — Polymerase chain reaction; *P. gingivalis - Porphyromonas gingivalis*; *P. intermedia - Prevotella intermedia*; PI-s — mean plaque index; PSM - Propensity score matching; SIgA - Secretory IgA; *T. forsythia - Tannerella forsythia*.

correlation, suggesting that changes in these two measurements were sporadic and independent.

Regarding burning mouth syndrome in menopausal women, Ozasa et al.[51] found that late postmenopausal patients with BMS showed significant hyperresponsiveness to thermal stimuli, with decreased pain thresholds to cold and heat compared to control groups.

The prevalence of burning mouth symptoms was recorded at 4.6 % in a sample of women aged between 38 and 84 in the study by Hakeberg et al..[35] This study found associations between BMS and systemic factors such as antihypertensive and hormonal medication, as well as local symptoms such as dry mouth and facial pain. However, there was no significant correlation between dental health and symptoms of subjective intraoral manifestations, suggesting that factors other than oral health influence these symptoms.

Lončar-Brzak et al.[49] showed that salivary oestradiol levels were significantly lower in patients with BMS. On the other hand, no significant correlation was found between salivary hormone levels and patients' perceived quality of life, as measured by the OHIP-14 questionnaire, which suggests that other factors, such as anxiety or depression, may have a greater influence on the perception of MSI symptoms.

Studies on the impact of HRT on periodontal and dental health were also analysed. In this context, the study by Han et al.[44] showed that the use of HRT was associated with a greater number of natural teeth in postmenopausal women, thus reducing the risk of tooth loss. The results indicated that women on HRT were more likely to have more than 20 natural teeth. Also, the study by López-Marcos et al.[37] examined the impact of HRT on the periodontal characteristics of these women, showing that this therapy was a protective factor against dental pain, tooth mobility and the formation of periodontal pockets; however, there was no significant effect on gingival recession.

Furthermore, the study by Lee et al.[48] found that HRT was associated with lower prevalence of periodontal disease.

These results are supported by the study by Ahn and Lee[47] which highlighted that women using HRT had better periodontal health in terms of bone density, particularly in the alveolar bone region. This improvement in bone health was associated with the replacement of oestrogen levels, which may have beneficial effects in preventing bone loss in the periodontal region.

Another important effect of HRT was reported in the study by Mahesh et al.,[42] which found that treated women showed an improvement in salivary flow, pH and buffering capacity compared to those without treatment. Furthermore, Wang et al.[50] observed that after HRT, oestradiol levels increased, and dry mouth decreased significantly. On the other hand, Tarkkila et al.[38] concluded that HRT did not significantly alter salivary flow, number of teeth or periodontal indices. This study showed that although HRT did not result in significant differences in clinical periodontal health, it did lead to a significant reduction in the presence of periodontal pathogens, namely *Porphyromonas gingivalis* and *Tannerella forsythia*.

Table 6 Description of results of selected studies concerning the 3 stages (puberty, pregnancy and menopause).

Authors[reference]	Type of study	Study objective	Methodology	Results
Saluja et al.[52]	Case-control clinical study	To evaluate the effects of menstruation, pregnancy and menopause on salivary flow rate, pH and taste function.	- Sample: 120 women divided into 4 groups (control, menstruating, pregnant, post-menopausal). - Analysis: saliva production stimulated by paraffin chewing, collected, pH measured electronically, and taste test carried out with specific solutions.	- Significantly lower pH in postmenopausal women. - Perception of sweet taste was lower in postmenopausal women. - Food preference for sweet foods observed in the post-menopausal group.
Alzoman et al.[53]	Cross-sectional study	To investigate the effect of hormonal changes on self-perceived halitosis in women.	- Sample: 1089 participants via online questionnaire on hormonal health, perception of halitosis and social impacts.	- 61.8 % of the women reported halitosis. - Perception of halitosis varied with menstrual irregularities and hormonal disorders. - Social impact of halitosis more evident among women with hormonal disorders.
Sindhusha et al.[54]	Analytical cross-sectional study	Comparing salivary pH, taste function and dental caries among women during puberty, menstruation and menopause.	- Sample: 60 women divided into 3 groups. - Analysis: pH measured with strips, taste test and caries assessment via the DMFT index.	- Significantly lower pH and higher DMFT in menopausal women. - Lower perception of sweet and bitter flavors in the post-menopausal group. - Correlation between low salivary acidity and increased caries.

DMFT index - Decayed, missing and filled teeth index.

Hormonal impact on oral health of the woman — comparative studies (puberty, pregnancy and menopause)

Three articles were included in this topic, and their results are described in Table 6.

The comparative study by Saluja et al.[52] revealed significant differences between the menstrual, pregnancy and menopause groups in salivary and taste parameters. Although salivary flow did not differ significantly between the groups, post-menopausal women showed a significant reduction in salivary pH. In terms of taste function, the intensity of sweet flavour perception was lower in post-menopausal women, who preferred sweeter foods. However, no significant variation was observed for salty, sour and bitter flavours.[52,54] In terms of DMFT (decayed, missing and filled teeth), postmenopausal women obtained the highest scores, suggesting that hormonal changes during this period may favour the development of dental caries. These women have also changed their eating habits, favouring sweeter foods.

Discussion

Puberty marks a decisive phase in a woman's hormonal life, characterized by the activation of the hypothalamic-pituitary-ovarian axis and the establishment of the menstrual cycle. Cyclical hormonal fluctuations, particularly in estrogen and progesterone, have a direct influence on many tissues, including the oral mucosa and periodontal structures. These hormonal variations during the menstrual cycle, with hormonal peaks observed during the ovulatory and premenstrual periods, lead to the modulation of pro-inflammatory cytokines, such as IL-6 and TNF-α, and can generate a transient gingival inflammatory response, without significantly altering tooth mobility or probing depth in periodontally healthy patients.

Some hormonal situations, such as the menstrual cycle or the use of oral contraceptives, have been suggested as factors that can increase tooth mobility due to biochemical changes in the tooth's supporting tissues. Female sex hormones are thought to reduce the periodontium's ability to resist occlusal forces, leading to transient mobility.[23]

According to Rateitschak (Tooth mobility changes in pregnancy, 1967, cited by[23]), this increased mobility is not due to a change in bone, but rather to an increase in initial intra-alveolar movement, associated with greater vascularization of the periodontal membrane. Estrogen and progesterone are known to increase capillary permeability, promoting localized gingival oedema, which may explain a slight increase in mobility at certain stages of the cycle.

In fact, some authors report a slight increase in horizontal mobility during the fourth week of the cycle, indicating a possible individual sensitivity.[55] However, Mishra et al.[23] reported no significant variations in mobility throughout the cycle. This same study, regarding gingival status, revealed an exacerbated inflammatory response during ovulation and the premenstrual phase, characterized by an increase in the gingival index, without an increase in plaque. This inflammation seems to be related to the peaks in estradiol and progesterone observed before ovulation and on the eve of menstruation, which modulate inflammatory mediators such as prostaglandins, TNF-α and IL-6.[23] This phenomenon suggests that the gingiva may act as a target tissue for sex hormones, showing greater inflammatory susceptibility in cases of pre-existing inflammation.[23] These results were confirmed in the study by Khosravisamani et al.[24] who provided strong evidence that the menstrual cycle, by inducing hormonal fluctuations, influences the inflammatory state of the periodontium, even in the absence of obvious pathology. Like Mishra et al.,[23] this study showed a significant relationship between the ovulatory or premenstrual phase and an increase in inflammatory markers, particularly TNF-α, as well as a moderate but measurable clinical exacerbation of gingival inflammation.

Furthermore, Aydınyurt et al.[25] suggest a transient inflammatory sensitivity of the gingival tissues in response to hormonal fluctuations, without any really profound structural changes. These results corroborate certain previous observations,[55,56] which attribute part of the periodic gingival inflammation to increased vascular permeability and the stimulation of inflammatory mediators induced by progesterone and estradiol. However, the differences in results observed in other studies[57,58] remind us that it is necessary to take into account inter-individual factors - age, genetics, cumulative hormonal exposure. Like the studies cited above, Aydınyurt et al.[25] show a clear relationship between the hormonal fluctuations of the menstrual cycle and variations in the mediators of gingival inflammation, namely IL-6 and TNF-α. Even in the absence of serious clinical signs, these biological changes suggest a greater vulnerability of the periodontium during certain phases of the cycle.

However, in women with a healthy periodontium, these hormonal changes appear to be mild and transient, with no significant clinical effects on tooth mobility or probing depth.

These results reinforce the idea that women should benefit from careful periodontal management during periods of hormonal variation, and that clinicians should consider these phases as potentially critical moments in the management of gingival health.

Regarding studies focusing on pregnancy, in addition to the fundamental role of this stage in the genesis of life, pregnancy imposes a profound and systemic hormonal rebalancing on the female organism, the clinical repercussions of which are often underestimated. This endocrine disturbance, centered on progesterone, estrogens and other key hormones such as cortisol and hPL, acts as a silent conductor over a multitude of biological systems, including the oral sphere.

Data provides converging evidence that pregnancy, through the increase in female sex hormones, is an important factor in aggravating periodontal disease, particularly gingivitis. Gingival inflammation is more frequent and more severe, particularly in the third trimester, when hormone levels are higher. Although oral hygiene remains a key element in the prevention of periodontal disease, these studies emphasize the need to systematically integrate oral health into antenatal care protocols, particularly in public

health units. Education and preventive management strategies must be put in place to limit periodontal complications, which can have obstetric repercussions.

On the other hand, regarding oral microbiome, the study by Yang et al.[33] clearly showed that an increase in salivary steroid hormones (progesterone, estradiol, testosterone and cortisol) significantly increases the cariogenic bacterial load, particularly that of *S. mutans*. This result corroborates the hypothesis that pregnancy, by changing the hormonal and immune landscape, favors an oral environment that is conducive to microbial imbalance. The studies analyzed point to pregnancy as a hormonal context that modifies the gingival immune response, facilitates the installation of pathogenic biofilm and amplifies local inflammatory reactions. This suggests that hormonal status alone can be a risk factor for caries, independent of hygiene habits, which calls for greater vigilance on the part of health professionals and the systematic inclusion of dental care in antenatal care.

Furthermore, the study by Africa & Turton,[2] although it did not measure hormone levels, shows that the clinical consequences of these changes manifest themselves in the form of various oral lesions, including epulides, aphthous ulcers and fungal infections. These pathologies are even more frequent in a disadvantaged socio-economic context. Lack of access to healthcare, lack of oral health education and cultural barriers make the situation even worse.

The studies converge on a crucial point: the need for systematic oral screening during pregnancy. In this context, Yang et al.[33] suggest using saliva as a non-invasive biomarker to predict the risk of caries, while Africa & Turton[2] advocate the need for greater collaboration between midwives, doctors and dentists in order to prevent complications. This observation is very important since the repercussions not only affect the mother but can also influence the oral health of the fetus.

Taken together, the studies illustrate the multiple facets of the impact of pregnancy on oral health. Biologically, hormonal changes modulate the state of oral tissues, increasing vascular sensitivity and gingival permeability, favoring the appearance of lesions.[1] These changes are often reversible after childbirth, but can lead to significant discomfort and, if left untreated, complications.

The study by Minervini et al.[31] sheds lighter on the subject, showing that pregnancy is not in itself a risk factor for TMD. Instead, these researchers report that psychological factors, particularly depression, appear to influence pain and jaw dysfunction, emphasizing the importance of an integrative approach that includes mental health in the management of orofacial disorders in pregnant women.

The study by Al Agili[30] shows a worrying discrepancy between the real clinical needs of pregnant women and the care they actually receive. This study highlights a persistent mistrust of dental care during pregnancy - sometimes shared by carers - and a lack of training for dentists in antenatal care. This results in underutilization of public dental health services, over-reliance on prescription drugs and often inadequate treatment.

All the analyzed studies show that hormonal changes that occur during pregnancy have a significant influence on the oral ecosystem of pregnant women. These studies show a marked increase in gingivitis, tooth mobility and caries risk, even in women with good oral hygiene. Pregnancy therefore acts as a local susceptibility factor, amplifying the gingival inflammatory response and favoring imbalances in the oral microbiome. Therefore, there is an urgent need to strengthen awareness-raising and training programs for health professionals to demystify preconceived ideas about the risks of dental treatment during pregnancy. The systematic inclusion of oral health in antenatal consultations could significantly improve the well-being of pregnant women and reduce potential complications for the fetus.

Finally, analyzing the articles selected on menopause, it is observed that the oral health of postmenopausal women is influenced by the reduction in estradiol levels, which has a direct effect on the function of the salivary glands. In addition, the reduction in 17β-estradiol also seems to have an impact on the mental state of the participants, reinforcing the idea that hormonal changes influence various aspects of women's lives during this period.[46] This idea was emphasized by Krupa et al.[3] who referred to the complexity of factors that influence oral health, suggesting that modifiable factors such as oral hygiene and access to healthcare can play an important role in mitigating the effects of menopause on oral health. Ben Aryeh et al.[34] also mentions psychological stress as a contributing factor to the worsening of oral disorders during the menopause. The high prevalence of xerostomia and the correlation between oral symptoms and systemic manifestations, such as hot flushes, support this idea of interaction between general health and oral health.

Regarding periodontal health, postmenopausal women show a high prevalence of periodontitis, with high rates of plaque and gingival inflammation. Prolonged menopause is associated with an increased risk of severe periodontal disease.[43] This link is reinforced by Takahashi et al.,[41] who observed a negative correlation between clinical attachment loss and lumbar and femoral BMD, suggesting that this systemic bone loss may exacerbate periodontal disease.

Regarding microbial agents, the bacterial strains *Tannerella forsythia* and *Campylobacter rectus* were identified in all periodontal samples, although a significant relationship with osteoporosis was not established. However, osteoporosis is well correlated with tooth loss in women with low BMD.[7,40,45]

Hormonal changes, particularly the fall in estrogen, can affect somatosensory function, making postmenopausal women more sensitive to thermal pain in the oral cavity.[51] Moreover, menopause has been linked to the prevalence of BMS, associated with drug treatments (antihypertensives, hormone therapy), dry mouth and facial pain.[35]

Regarding the impact of HRT on the oral health of menopausal women, several studies indicate beneficial effects on oral health, such as the retention of a greater number of natural teeth,[44] a protective effect against tooth mobility, pain and the formation of periodontal pockets,[37] although no improvement in gingival recession was observed. These results have been associated with an increase in alveolar bone density resulting from the restoration of estrogen levels.[47,48]

HRT also led to an improvement in salivary flow, pH and the buffering capacity of saliva, as well as a significant

reduction in the sensation of dry mouth.[42,50] A reduction in the presence of pathogens such as *P. gingivalis* and *T. forsythia* was also observed.[38]

Overall, these results confirm that the hormonal decline associated with the menopause has a considerable impact on oral health, affecting both objective parameters (salivation, bone density, periodontal status) and subjective symptoms. HRT appears to be a potentially beneficial intervention, although its effectiveness varies according to the individual. A multidisciplinary approach, taking into account hormonal, psychological and behavioral factors, seems essential to preserve the oral health of postmenopausal women.

In short, all the studies analyzed point to the importance of a preventive and personalized approach to the care of adolescents during puberty, pregnant women and menopausal women, since the hormonal changes that occur during these stages of life make the gingival tissue more reactive, even in the absence of obvious pathology. Integrating this hormonal dimension into oral health care practices is therefore essential to ensure optimal oral health.

In conclusion, it is essential that dental health professionals take hormonal variations into account when managing women's oral health, particularly after the menopause, in order to effectively prevent and treat dental problems associated with these hormonal changes.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgments

This research was supported by Fernando Pessoa Teaching and Culture Foundation.

References

1. Annan BDRT, Nuamah K. Oral pathologies seen in pregnant and non-pregnant women. *Ghana Med J* 2005;39:24—6.
2. Africa CWJ, Turton M. Oral health status and treatment needs of pregnant women attending antenatal clinics in KwaZulu-Natal, South Africa. *Int J Dent* 2019;2019:5475973.
3. Krupa NC, Thippeswamy HM, Chandrashekar BR, Thetakala RK. Impact of menopausal duration on salivary flow rate, tooth loss, and oral health-related quality of life in Indian communities. *J Mid-life Health* 2023;14:101—6.
4. Kessler JL. A literature review on Women's oral health across the life span. *Nurs Womens Health* 2017;21:108—21.
5. Levin RP. Pregnancy gingivitis. *J Md State Dent Assoc* 1987;30:27.
6. Silverstein LH, Burton Jr CH, Singh BB. Oral pyogenic granuloma in pregnancy. *Int J Gynaecol Obstet* 1995;49:331—2.
7. Kim CS, Kim EK, Lee KS, et al. Relationship between bone mineral density, its associated physiological factors, and tooth loss in postmenopausal Korean women. *BMC Womens Health* 2015;15:65.
8. Dural S, Gungor M, Çağırankaya B. Evaluation of the effect of menopause on saliva and dental health. *Hacettepe Dihekimlii Fakultesi Dergisi* 2006;30:15—8.
9. Thiyagarajan DK, Basit H, Jeanmonod R. *Physiology, menstrual cycle*. Treasure Island: StatPearls, 2024.
10. Varghese J, Khajuria A. Endocrine changes during pregnancy (a clinical updated review for a time-bound prospective study). *Santosh Univ J Health Sci* 2023;9:204—8.
11. Cole LA. Biological functions of hCG and hCG-related molecules. *Reprod Biol Endocrinol* 2010;8:102.
12. Albrecht ED, Pepe GJ. Central integrative role of oestrogen in modulating the communication between the placenta and fetus that results in primate fecal-placental development. *Placenta* 1999;20:129—39.
13. Handwerger S, Freemark M. The roles of placental growth hormone and placental lactogen in the regulation of human fetal growth and development. *J Pediatr Endocrinol Metab* 2000;13:343—56.
14. Meurman JH, Tarkkila L, Tiitinen A. The menopause and oral health. *Maturitas* 2009;63:56—62.
15. Suri V, Suri V. Menopause and oral health: a comprehensive review on current knowledge and associated dental management. *J Mid Life Health* 2014;5:115—20.
16. Pearson A, Wiechula R, Court A, Lockwood C. The JBI model of evidence-based healthcare. *Int J Evid Base Healthc* 2005;3:207—15.
17. Pearson A, Jordan Z, Munn Z. Translational science and evidence-based healthcare: a clarification and reconceptualization of how knowledge is generated and used in healthcare. *Nurs Res Pract* 2012;2012:792519.
18. Jordan Z, Lockwood C, Munn Z, Aromataris E. The updated Joanna Briggs Institute model for evidence-based healthcare. *Int J Evid Base Healthc* 2019;17:58—71.
19. McGowan J, Sampson M, Salzwedel DM, Cogo E, Foerster V, Lefebvre C. PRESS peer review of electronic search strategies: 2015 guideline statement. *J Clin Epidemiol* 2016;75:40—6.
20. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan - a web and mobile app for systematic reviews. *Syst Rev* 2016;5:210.
21. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Syst Rev* 2021;10:89.
22. Balan U, Gonsalves N, Jose M, Girish KL. Symptomatic changes of oral mucosa during normal hormonal turnover in healthy young menstruating women. *J Contemp Dent Pract* 2012;13:178—81.
23. Mishra P, Marawar PP, Byakod G, Mohitey J, Mishra SS. A study to evaluate mobility of teeth during menstrual cycle using periotest. *J Indian Soc Periodontol* 2013;17:219—24.
24. Khosravisamani M, Maliji G, Seyfi S, et al. Effect of the menstrual cycle on inflammatory cytokines in the periodontium. *J Periodontal Res* 2014;49:770—6.
25. Aydınyurt HŞ, Yuncu YZ, Tekin Y, Ertugrul AS. IL-6, TNF—α levels and periodontal status changes during the menstrual cycle. *Oral Dis* 2018;24:1599—605.
26. Onigbinde O, Sorunke M, Braimoh M, Adeniyi A. Periodontal status and some variables among pregnant women in a Nigeria tertiary institution. *Ann Med Health Sci Res* 2014;4:852—7.
27. Mishra PS, Marawar PP, Mishra SS. A cross-sectional, clinical study to evaluate mobility of teeth during pregnancy using periotest. *Indian J Dent Res* 2017;28:10—5.
28. Ruiz Candina HJ, Herrera Batista AJ, Padrón ET Fonte. Enfermedad periodontal en gestantes del primer y tercer trimestre del embarazo. *Rev Cubana Invest Bioméd* 2018;37:18—21.
29. Costa NB, Silva EM. Prevalência da doença periodontal em gestantes de uma unidade básica de saúde em Natal/RN. *Rev Ciência Plural* 2020;6:71—86.
30. Al Agili D. Trends in maternal oral health services at primary healthcare centers in Saudi Arabia: a cross-sectional study. *BMC Oral Health* 2023;23:1031.

31. Minervini G, Marrapodi MM, La Verde M, et al. The relationship between pregnancy and temporomandibular disorder (TMD) through diagnostic criteria for temporomandibular disorders (DC/TMD) axis II evaluation: a case-control cross-sectional study. *BMC Oral Health* 2024;24:342.
32. Sachelarie L, Iman AElH, Romina MV, Huniadi A, Hurjui LL. Impact of hormones and lifestyle on oral health during pregnancy: a prospective observational regression-based study. *Medicina* 2024;60:1773.
33. Yang R, Lu X, Alomeir N, Quataert S, Wu T, Xiao J. Association between salivary hormones, dental caries, and cariogenic microorganisms during pregnancy. *J Clin Med* 2024;13:3183.
34. Ben Aryeh H, Gottlieb I, Ish-Shalom S, David A, Szargel H, Laufer D. Oral complaints related to menopause. *Maturitas* 1996;24:185—9.
35. Hakeberg M, Berggren U, Hagglin C, Ahlqwist M. Reported burning mouth symptoms among middle-aged and elderly women. *Eur J Oral Sci* 1997;105:539—43.
36. Pilgram TK, Hildebolt CF, Dotson M, et al. Relationships between radiographic alveolar bone height and probing attachment level. *J Periodontol* 2000;71:491—6.
37. López-Marcos JF, García Valle S, García-Iglesias ÁA. Periodontal aspects in menopausal women undergoing hormone replacement therapy. *Med Oral Patol Oral Cir Bucal* 2005;10:132—41.
38. Tarkkila L, Furuholm J, Tiitinen A, Meurman JH. Oral health in perimenopausal and early postmenopausal women from baseline to 2 years of follow-up with reference to hormone replacement therapy. *Clin Oral Invest* 2008;12:271—7.
39. Tarkkila L, Kari K, Furuholm J, Tiitinen A, Meurman JH. Periodontal disease-associated microorganisms in peri-menopausal and post-menopausal women using or not using hormone replacement therapy. A two-year follow-up study. *BMC Oral Health* 2010;10:10.
40. Makker A, Singh MM, Mishra G, Singh BP, Jain GK, Jadhav S. Relationship between bone turnover biomarkers, mandibular bone mineral density, and systemic skeletal bone mineral density in premenopausal and postmenopausal Indian women. *Menopause* 2012;19:642—9.
41. Takahashi O, Yoshihara A, Nakamura K, Miyazaki H. Association between periodontitis and systemic bone mineral density in Japanese community-dwelling postmenopausal women. *J Dent* 2012;40:304—11.
42. Mahesh DR, KoMali G, Jayanthi K, Dinesh D, SaiKavitha TV, Preeti D. Evaluation of salivary flow rate, pH and buffer in pre, post & post menopausal women on HRT. *J Clin Diagn Res* 2014;8:233—6.
43. Deepa D, Jain G. Assessment of periodontal health status in postmenopausal women visiting dental hospital from in and around Meerut city: cross-sectional observational study. *J Midlife Health* 2016;7:175—9.
44. Han Y, Ko Y, Park YG, Park JB. Associations between the number of natural teeth in postmenopausal women and hormone replacement therapy. *Maturitas* 2016;94:125—30.
45. Hernández-Vigueras S, Martínez-Garriga B, Sánchez MC, et al. Oral microbiota, periodontal status, and osteoporosis in postmenopausal females. *J Periodontol* 2016;87:124—33.
46. Yoshida N, Sugimoto K, Suzuki S, Kudo H. Change in oral health status associated with menopause in Japanese dental hygienists. *Int J Dent Hyg* 2017;16:157—64.
47. Ahn E, Lee Y. The relationship between hormone replacement therapy and periodontal disease in postmenopausal women. *J Dent Hyg Sci* 2018;18:9—17.
48. Lee Y, Kim I, Song J, Hwang KG, Choi B, Hwang SS. The relationship between hormone replacement therapy and periodontal disease in postmenopausal women: a cross-sectional study based on the Korea National Health and Nutrition Examination Survey from 2007 to 2012. *BMC Oral Health* 2019;19:151.
49. Lončar-Brzak B, Vidranski V, Andabak-Rogulj A, et al. Salivary hormones and quality of life in female postmenopausal burning mouth patients — a pilot case-control study. *Dent J* 2020;8:111.
50. Wang L, Zhu L, Yao Y, Ren Y, Zhang H. Role of hormone replacement therapy in relieving oral dryness symptoms in postmenopausal women: a case control study. *BMC Oral Health* 2021;21.
51. Ozasa K, Noma N, Young A, Korczeniewska OA, Eliav E, Imamura Y. Potential differences in somatosensory function during premenopause and early and late postmenopause in patients with burning mouth syndrome: an observational case—control study. *J Dent Sci* 2022;17:399—406.
52. Saluja P, Shetty VP, Dave A, Arora M, Hans V, Madan A. Comparative evaluation of the effect of menstruation, pregnancy, and menopause on salivary flow rate, pH and gustatory function. *J Clin Diagn Res* 2014;8:ZC81—5.
53. Alzoman H, Alssum L, Helmi M, Alsaleh L. Relationship between hormonal changes and self-perceived halitosis in females: a cross-sectional study. *Healthcare* 2022;11:43.
54. Sindhusha BS, Srinivas R, Pachava S. Comparative evaluation of salivary pH, gustatory function, and dental caries among pubertal, menstruation, menopause women — an analytical cross-sectional study. *J Indian Assoc Public Health Dent* 2024;22:362—6.
55. Machtei EE, Hirsch I, Shemesh R. Gingival inflammation and supragingival plaque during the menstrual cycle. *J Periodontol* 2004;75:1392—6.
56. Güncü GN, Tözüm TF, Çaglayan F. Effects of endogenous sex hormones on the periodontium — review of literature. *Aust Dent J* 2005;50:138—45.
57. Baser U, Cekici A, Tanrikulu-Kucuk S, Kantarci A, Ademoglu E, Yalcin F. Gingival inflammation and interleukin-a beta and tumor necrosis factor-alpha levels in gingival crevicular fluid during the menstrual cycle. *J Periodontol* 2009;80:1983—90.
58. Becerik S, Ozçaka O, Nalbantsoy A, et al. Effects of menstrual cycle on periodontal health and gingival crevicular fluid markers. *J Periodontol* 2010;81:673—81.