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Research Article

Additive Effect of Stress Factors on Dental Status: A Comprehensive Analysis of Relationships (Literature Review)

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Abstract

The purpose of the study is to conduct a systematic analysis of modern data on the principle of additivity of errors in a comprehensive assessment of dental status, taking into account the influence of stress factors and general adaptation syndrome on diagnostic accuracy.

Methodology: An analysis of 53 scientific sources (1960-2025) was carried out, including:

- Methodological articles;
- Consensus reports;
- Systematic reviews;
- Clinical guidelines;
- Monographs;
- Textbooks.

Results: In the course of the study, it was found that the total error of the comprehensive assessment of dental status demonstrates a high correlation with the sum of errors of individual components [29,39,46], which indicates the cumulative nature of diagnostic errors.

The mean deviation is (95% confidence interval:). The structure of the contribution of various sources of error to the total error is as follows: subjective methods — 45-60%; instrumental methods — 20-30%; methodological errors are 15-25%.

In addition, it was revealed that stress factors introduce an additional error in the range of 20-50% and more, which is currently practically not taken into account in existing diagnostic models (methods).

Thus, the principle of additivity of errors requires that the influence of stress factors be taken into account in a comprehensive assessment of dental status. To minimize diagnostic errors, it is necessary to implement the following measures:

- Optimize the set of valuation methods used;
- Standardize diagnostic protocols;
- Calibrate researchers;
- To introduce control systems that ensure the objectification of taking into account the influence of stress factors and general adaptation syndrome in a comprehensive assessment of dental status.

Keywords: Dental Status; Stress; Comprehensive Assessment; Additivity of Errors; Diagnostic Accuracy; General Adaptation Syndrome; Methodology

The influence of stress on the indicators of dental status: General adaptation syndrome as a modulator of diagnostic accuracy

The additive effect of stress factors on dental status is a complex process in which the combined effect of several stressors increases the negative impact on oral health. A comprehensive analysis of the relationship between stress and dental status includes the study of physiological, biochemical and behavioral mechanisms, as well as the assessment of their additive effect. "Stress is a non-specific (atypical) response of the body to any demand presented to it, It is impossible to live without stress (stressor-stimulus)." At the same time, it was clarified that there is eustress (adaptation, mobilizing the resources of the body without harm to its health and aimed at ensuring the homeostasis of the body and its adaptation to the conditions of the human environment) and distress (stress leading to the development of various pathologies up to the death of the organism - weakening and depletion of the adaptive reserves of the body, its organs and systems). In assessing the adaptive capabilities of the organism in normal and pathological conditions, G. Selye developed the theory of OSA and an algorithm of its clinical and physiological manifestations, which explains both the manifestation of eustress and distress.

As applied to dentistry, the question of how stress changes the metabolic, physiological and clinical indicators of the oral cavity (in normal and pathological conditions) at all levels - from molecular to organ in unity, in the interconnection of all its components has not been sufficiently studied.

An integral analysis of this concept shows that OSA acts as an active modulator of dental status [35,36], and not just a background factor, which requires its mandatory consideration in diagnostic studies.

A critically important aspect is that the dental appointment procedure itself is already a stressor [35,39]. It causes multivariate changes in the parameters of oral cavity biotopes at all levels [17,35] and creates an additional source of diagnostic errors that are not taken into account in traditional additivity models [1,3]. At the same time, the contribution of iatrogenic stress can increase the overall diagnostic error by 20-40% [36,39].

OSA includes three phases, each of which has a specific effect on the indicators of dental status (in normal and pathological conditions):

- **Anxiety phase:** The sympathoadrenal system is activated with the release of adrenaline, noradrenaline, and cortisol. This leads to a temporary improvement in gingival perfusion and a short-term increase in salivation (observed in ~30% of patients). Such dynamics can create a false impression of an improvement in dental status [35], which is fraught with false-negative diagnostic results in 5-12% of cases [22-24].

- **Resistance phase:** Adaptation occurs with the activation of immune mechanisms, a change in the composition of saliva and a shift in the microbiome. Clinically, this is manifested by:

    - the growth of populations of *S. mutans*, *P. gingivalis*, *C. albicans*;
    - reducing the levels of sIgA and lysozyme;
    - the development of gingivitis and caries (observed in ~50% of patients).
    - This phase is critical for the development of dental diseases [17,35] and can lead to false positive diagnostic results in 8-15% of cases [1,4,37].

- **Exhaustion phase:** Immunosuppression, hyposalivation, impaired microvascularization and imbalance of redox processes develop. The consequences are:

    - chronic periodontitis;
    - mucosal atrophy;
    - candidiasis;
    - accelerated caries;
    - non-healing ulcers (observed in ~70% of patients).

This phase poses the greatest danger to dental health [35,36] and can increase the diagnostic error by 30-50%.

In general, the general adaptation syndrome (OSA), known as the manifestation of stress, negatively affects the tissues and organs of the oral cavity and its dental status. This is expressed in:

- **Disruption of the immune system**: The body stops fighting pathogens, which increases the risk of developing inflammatory processes in the oral cavity. If there have already been problems with teeth, then they only get worse. dr-martin.ru

- **Changes in insulin levels in the blood:** High blood sugar is dangerous for the vessels that nourish the tissues of the gums and teeth. dr-martin.ru
- **Increased catecholamine levels**: These are hormones that are contained not only in the adrenal glands, but also in the pulp of the tooth, and are responsible for the production of adrenaline. Under stress, there is a sharp jump in catecholamines, which can lead to severe toothache and the development of pulpitis. dr-martin.ru
- **Gallbladder dysfunction**: The release of bile does not occur in the duodenum, but in the stomach. In cases where the lower esophageal sphincter is open, it also enters the oral cavity. This leads to the destruction of tooth enamel and irritation of the oral mucosa. dr-martin.ru

These pathological conditions that occur against the background of stress lead to the occurrence and development of various dental diseases (especially with prolonged exposure):

- Caries - destruction of tooth enamel and internal tissues of the tooth; dr-martin.ru
- Stomatitis - inflammation of the oral mucosa, in which papules, ulcers and erosions can form; dr-martin.ru
- Gingivitis - inflammation of the gums that occurs without affecting the teeth; dr-martin.ru
- Periodontitis - inflammation of the tissues surrounding the tooth, which can lead to its loss; dr-martin.ru
- Hyperesthesia - increased sensitivity of the teeth; dr-martin.ru
- Bruxism - teeth grinding during sleep; dr-martin.runovadent.ru
- Periodontitis - inflammation of the connective tissue surrounding the root of the tooth; dr-martin.ru
- Temporomandibular joint dysfunction - limitation of mandibular movements, pain, crunching and clicking in the TMJ. dr-martin.ru

Treatment of the consequences of chronic stress involves an integrated approach. In addition to a dentist, the patient may need the help of a psychologist, endocrinologist, neurologist or other specialists. dr-martin.ru.

This issue is studied in the work of the authors Huling L. B., Baccaglini L., Choquette L., Feinn R. S., Lalla R. V. "The effects of stress on general and oral health are increasingly recognized" (2012), which presents studies of the impact of stress on general and dental health. The authors [35] emphasize that the relationship between psycho-emotional stress and the state of the oral cavity is obvious.

This is evidenced by the following data:

- **Mechanisms of stress influence on the body:** Stress triggers a cascade of biochemical reactions, including the release of the hormones cortisol and catecholamines (adrenaline, noradrenaline). These substances prepare the body for "fight or flight", but with chronic stress, they disrupt the immune and nervous systems, increase inflammatory reactions and distort pain sensitivity. stomsmile.ru +2
- **Effects on the immune system:** Chronic stress suppresses the immune response, which makes oral tissues (gums, mucous membranes, periodontium) more vulnerable to infections. Weakened immunity contributes to the development of inflammation and slows tissue healing. stomsmile.ru +2
- **Bruxism and TMJ dysfunction:** Stress is one of the leading factors contributing to involuntary teeth grinding (bruxism) and jaw clenching. This leads to excessive strain on the teeth: enamel abrasion, cracks, chips, exposed dentin tubules and hypersensitivity. The temporomandibular joint (TMJ) is also affected, which can cause pain in the jaw, neck and head. stomsmile.ru +2
- **Decreased salivation (xerostomia):** Stress reduces the production of saliva, which has a protective function: it washes away food debris, neutralizes acids produced by bacteria, and contains antibodies and minerals to protect teeth. Dry mouth increases the risk of tooth decay, infections, and the proliferation of anaerobic bacteria that cause periodontal disease. 100med.ru +2
- **Inflammatory gum disease:** Under the influence of stress, blood vessels constrict, the gum tissues receive less oxygen and nutrients. This reduces their protective function, suppresses local immunity and contributes to the development of gingivitis (inflammation of the gums) and periodontitis (inflammation of the tissues around the tooth). dzhmao.ru +2

- **Changes in behavior:** In stressful situations, people often neglect oral hygiene (skip brushing their teeth), change eating habits (eat more sweets), resort to bad habits (smoking, drinking alcohol). All this negatively affects the health of teeth and gums. vivadent71.ru +2
- **Psychosomatic manifestations:** Stress can cause paresthesias - disruption of the conduction of nerve endings, due to which the brain receives distorted signals perceived as pain. Also, against the background of emotional stress, conditions such as recurrent aphthous stomatitis (painful mouth ulcers), burning mouth syndrome, oral lichen planus can exacerbate.stomsmile.ru +2

In conclusion, the authors [35] emphasize that stress significantly affects the state of the oral cavity, increasing the risk of developing caries, inflammatory gum disease, bruxism and other problems. To minimize the negative consequences, it is important not only to treat dental diseases, but also to work on stress management in order to normalize the psycho-emotional state of the patient, which is facilitated by maintaining oral hygiene and regular visits to the dentist. Thus, This study, like the scientific works of other authors, focuses on the need for an integrated approach to the dental health of the patient, taking into account both physical and psycho-emotional factors [40,44-48].

The key conclusion of the analysis of stress and its manifestations in the form of OSA is that it is not a background, but an active modulator of dental status [15,35]. Dental changes under stress are not a consequence of neglect of hygiene, but a manifestation of systemic maladaptation [8,35,36]. This one apparently needs to be developed. a fundamentally new approach to the diagnosis and treatment of dental diseases [7,10,13,16,18,19,25-27,48].

Empirical data from the study by Prikule D. V., Aleksandrov M. T., Kukushkin V. I. (2018) [39] — the only one in the Russian literature where multifactorial numerical indicators of dental status objectively measured before and after stress load in healthy students without somatic pathology (in their unity and interaction) — confirm this concept. Exceeding 50% in all indicators. At the same time, the changes in indicators under stress are 2-5 times greater than the changes after hygienic treatment (20-80%), which means that under stress, even a “clean” mouth can look like a “pathological” mouth, and vice versa [31-33].

Specific results of the study (39) testify to this:

- **EDI (electroodontodiagnostics):** An increase of 46.5% followed by a decrease of 23.2%;
- **Saliva pH:** 3.5% decrease
- **Gingival temperature:** 0.62 °C increase;
- **Stange test:** 31.5% increase in recovery time followed by a 19.3% decrease;
- **Sheikhzadeh’s formula:** 57.2% increase in voltage followed by 18.6% decrease;
- **Saliva fluorescence: S**ignificant changes in spectral characteristics by almost 8-10 times.

At the same time, as noted by a number of authors [39,50,51], after the negative impact of the stress factor (test, exam, physical activity) was stopped, the studied indicators returned to the pre-existing ones (additive error in the assessment of dental status according to the above data was more than 1000% - according to V.Y. Urbakh, Biomeria, 1964).

The most important postulate of the research is the presence of a synergetic effect: the total error can reach 115% or more of the theoretical sum of component errors [28,29]. This means that the errors of different methods of assessing dental status are not just summed up, but mutually reinforce each other, creating a cumulative effect that exceeds a simple arithmetic sum. An integral assessment of this phenomenon shows that its severity increases significantly in the presence of stress factors [35,36], especially in conditions of chronic stress, where the processes of disadaptation of the body arise and prevail (the phase of OSA depletion).

According to the authors [35,36], additivity also occurs when several stressors (for example, occupational stress, emotional stress, chronic diseases) act simultaneously, reinforcing each other. For example:

- The combination of occupational stress and harmful working conditions (noise, vibration) increases the risk of non-carious tooth lesions (wedge-shaped defects, enamel erosion).
- The combined effects of stress and malnutrition (frequent sugary snacks) increase the risk of tooth decay.

- Chronic stress combined with genetic predisposition can accelerate the development of periodontitis by increasing inflammatory and destructive processes. vmeda.mil.ru +1

Studies show that people with high levels of anxiety are more likely to have periodontal tissue disease, and their levels of cortisol in their mouths are significantly higher than those with low levels of anxiety. It has also been established that high anxiety can be an occlusive factor in the development of non-carious tooth lesions.

The complex nature of the interaction of diagnostic errors in the comprehensive assessment of dental status can be described by the following recommendations presented in the scientific literature (accounting for the main errors):

- Error of the diagnostic component [13,14];
- Significance weights [25];
- Correlation coefficients between errors [28,29];
- Systematic errors [30];
- Additional error due to stress factors [35,39].

An integral assessment of these errors (according to a number of authors-.4, 42) will allow us to show that taking into account stress factors will increase its adequacy by 20-30% (according to preliminary data).The authors consider it especially important to take into account the OSA phase, since in the phase of anxiety the correlation coefficients may be lower due to a short-term improvement in certain indicators, while in the phase of exhaustion they increase sharply due to multiple violations of oral homeostasis Their implementation is waiting for its researcher.

Clinical consequences, their qualitative and quantitative assessment, practical significance in relation to dentistry.

The additive nature of diagnostic errors has serious, quantitatively and qualitatively registered clinical consequences, which, in relation to dentistry, manifest themselves in three main forms.

False positive results

They occur in 8-15% of cases [1,4,37] and lead to the following negative consequences:

- Unjustified treatment - 5-9% of cases;
- Iatrogenic injuries - 2-4% of cases;
- Psychological distress of patients - 1-2% of cases;
- Economic losses are additional costs of treatment [38].

This significantly reduces the effectiveness of dental care. Integral assessment shows that one of the key reasons for false positive results is the failure to take into account stress factors and their impact on the indicators of dental status [35,36]. The issue requires further study and development of medical and dental technologies to level these errors in relation to the objectivity of the assessment of dental status.

False negative results

They are observed in 5-12% of cases [22-24] and are accompanied by:

- Omission of initial caries - 3-6% of cases;
- Undiagnosed periodontitis - 2-4% of cases;
- Disease progression - 1-2% of cases.

The presented provisions may have economic consequences, which are expressed in the fact that the costs of treating complications are 3-5 times higher [38], which emphasizes the importance of timely and accurate diagnosis. Integral analysis indicates that such errors are often due to the peculiarities of the resistance phase of OSA, when adaptive mechanisms mask the initial manifestations of pathology [35].

Quantitatively, in relation to dentistry, these distortions occur in 10-20% of cases [25-27] and manifest themselves in the following forms:

- Overestimation of the degree of damage - 6-10% of cases;
- Underestimation of the severity of the disease — 4-8% of cases;
- Incorrect choice of treatment tactics - 2-4% of cases.

These distortions directly affect the quality of dental care [33,34] and the level of patient satisfaction [37,40]. The presented assessment indicates that a significant part of quantitative errors is associated with the failure to take into account the OSA phase and its specific impact on diagnostic indicators [35]. For example, in the phase of anxiety, there may be a temporary improvement in gingival perfusion, and in the phase of exhaustion, pronounced destructive changes, which, in the absence of correction for OSA, leads to a distortion of the real clinical picture of the disease.

That is why medical studies of recent years [33-35,37,39,40] are aimed at taking into account and reducing the additive effect of stress factors and phases of OSA on the therapeutic and diagnostic indicators of dental patients.

- Reduce the frequency of false positive and false negative diagnostic results;
- Optimize the choice of treatment tactics due to a more accurate assessment of the dental status;
- To reduce the economic costs of treatment by preventing unjustified interventions and complications;
- To increase patient satisfaction with the quality of dental care;
- To develop personalized diagnostic protocols, taking into account the patient's current adaptive state.

Thus, the integration of the concept of OSA into the clinical practice of dentists and its applied solution represents an important step towards improving the accuracy of diagnosis and the effectiveness of treatment, as well as reducing the economic costs of the healthcare system in dentistry.

Strategies for minimizing additive errors

Based on the analysis of the literature, the following effective strategies for minimizing additive errors have been identified, taking into account the principle of cumulativeness and the influence of stress factors.

Optimization of the set of diagnostic methods [2,5,7,14,16,22,49]:

- Use of the 3-4 most informative methods with the smallest integral error;
- Elimination of duplicate methods;
- Preference for objective quantitative methods (EDI, saliva pHmetry, fluorescence diagnostics).

The implementation of this strategy will allow, according to the authors, to reduce the overall error by 15-25%. At the same time, special attention is paid to the fact that it is critically important, in order to achieve the above result, to include methods of digital assessment of stress load (Stange test, Sheikhzadeh formula, analysis of the level of cortisol in saliva) [35,39].

Standardization of protocols [2,4,11,41,44]:

- Development of unified diagnostic algorithms;
- Unification of evaluation criteria;
- Introduction of digital protocols taking into account the CCA phase;
- Creation of protocols for accounting for stress factors.

At the same time, as noted [35], standardization helps to reduce methodological errors by 20-30% and increases the reproducibility of results.

Another aspect of the problem is the need for "calibration of researchers" [8,28,41], which, according to the authors, should also contribute to reducing diagnostic errors in assessing dental status by 25-35%, which will contribute to increasing the reliability of diagnostic conclusions.

To achieve these results, the authors recommend:

- Regular training and testing of the skills of dentists when working with equipment and modern methods of assessing the dental status;
- Assessment of agreement between experts (Kapp test);
- Training based on typical clinical cases, taking into account the stress background of patients, the features and patterns of its manifestation, objectification of its assessment and correction;
- Trainings on recognizing signs of stress and stages of OSA, with mandatory quality control of the acquired skills [15,42,43].

In addition to the above, the following medical technologies and algorithms are offered to dentists to objectify diagnostic indicators, register manifestations and level the general adaptation syndrome [35,36,51]:

- Assessment of the OSA phase in each patient (questionnaires, physiological tests);
- Application of methods of objective stress diagnosis:
  - Ramanfluorescence diagnostics;
  - EDI;
  - pHmetry of saliva;
  - Analysis of biomarkers of stress in the oral fluid;

- Correction of diagnostic algorithms taking into account the phase of stress;
- Personalization of diagnostic criteria.

According to the authors, the use of these methods will reduce the additional error by another 20-40%, which, in their opinion, will fundamentally increase the accuracy of a comprehensive assessment of dental status.

Thus, taking into account the cumulative and synergistic effects of diagnostic errors, as well as integrating the concept of stress and OSA as factors that perturb and/or distort the clinical picture of the disease and/or dental status (in normal and pathological conditions) into clinical practice will apparently significantly improve the accuracy and reliability of the comprehensive assessment of dental status, which corresponds to the purpose and objectives of this review.

Thus, the analysis of 53 scientific sources confirms that the principle of additivity of errors is a significant and proven methodological and methodological aspect that must be taken into account in a comprehensive, multivariate assessment of dental status [13,14,28]. However, in order to increase the objectivity and accuracy of diagnosis, it needs to be supplemented by taking into account the influence of stress factors and general adaptation syndrome (GSS) [35,36,39,51].

Key findings [2,4,33,38,34,42,44]:

- **Scientific validity in relation to dentistry:** The principle of additivity has a convincing theoretical justification [13,14] and empirical confirmation with high statistical significance (,) [28] in relation to the assessment of dental status. To increase the adequacy of dental diagnostic models, integration with the concept of AS is required [35], which will allow taking into account the synergistic interaction of diagnostic errors and stress factors in dental practice.
- **Quantitative characteristics in dentistry:** The exact parameters of errors of various diagnostic methods in dentistry have been established [21,29] and their contribution to the overall error in assessing the dental status [21,44]. This makes it possible to purposefully minimize errors in dental diagnostics [4,42], taking into account the additional error of 20-40% introduced by stress factors [35,36].
- **Clinical significance for dentistry:** The additive nature of errors leads to measurable clinical consequences in dental practice [1,4,37]:
- False positive results in dentistry — 8-15% of cases [1,4,37];
- False negative results in the assessment of dental status — 5-12% of cases [22-24].
- This directly affects the quality of dental care [33,34]. At the same time, stress factors increase the negative consequences for the accuracy of the diagnosis of dental diseases by 30-50% [35].
- **Effects of stress and OSA on dental status.** General adaptation syndrome acts as an active modulator of physiological processes [12-15], including dental status [35]:
- Causes changes in the diagnostic indicators of dental status by 50-100% or more even in healthy patients;
- Reduces the accuracy of dental diagnostics by 20-40%;

The dental appointment itself acts as an additional stress factor that increases the integral error in the assessment of dentistry.

- Dental status by 10-20%.

Integral assessment of errors in dental diagnostics

All components of diagnostic error in assessing dental status form an interrelated system [13,14], where stress factors play a key role in enhancing additive and synergistic effects [35]. This requires the development of comprehensive dental models that take into account both technical and psychophysiological aspects of diagnosing dental status.

Practical recommendations for dentistry

Strategies for minimizing errors in dental diagnostics [4] have been developed based on evidence-based data [42]:

- **Optimization of dental diagnostic methods [5,7,14]:** Reducing the number of diagnostic procedures to 3-4 of the most informative for assessing the dental status, eliminating duplicate techniques;
- **Standardization of dental protocols [2,4,11]:** Unification of criteria for assessing dental status, introduction of digital algorithms taking into account the phase of OSA;

- **Calibration of dental researchers [8,28,41]:** Regular training of specialists, assessment of agreement between experts in the interpretation of dental status data, use of reference clinical cases taking into account the stress background;
- **Quality control of dental diagnostics [15,42,43]:** Internal audit of diagnostic procedures in dentistry, feedback from researchers;
- **Taking into account OSA in dental practice [35]:** Assessing the stress phase of a dental patient, using objective methods for diagnosing stress (EDI, saliva pHmetry, biomarker analysis), and correcting the diagnostic criteria of dental status.

The implementation of these measures can reduce the overall error of dental diagnostics by 30-50%.

Prospects for development in dentistry

Directions for further research have been identified [40,44]:

- Development of personalized diagnostic algorithms in dentistry, taking into account the phase of OSA and the level of stress [25,39];
- Introduction of digital technologies for automatic correction of diagnostic indicators of dental status [40];
- Creation of international standards for a comprehensive assessment of dental status with the integration of stress load assessment [44];
- Study of the long-term effects of cumulative effects of stress on dental health;
- Development of mobile applications for monitoring stress reactions of dental patients before appointments.

Practical significance for dentistry

Taking into account the principle of additivity of errors with the integration of the influence of stress factors allows:

- To significantly increase the reliability of a comprehensive assessment of dental status [4,42];
- To optimize diagnostic algorithms in dentistry [2,4];
- To improve the quality of dental care and the accuracy of diagnosis of dental diseases [33,34];
- To reduce economic losses from diagnostic errors in dentistry by 25-40% [38,44];
- To ensure compliance with modern requirements for evidence-based dentistry [4,42] and quality standards of medical care in the field of dentistry [44].

Conclusion

Thus, the additive effect of stress factors on dental status requires an integrated approach that takes into account both direct physiological effects and behavioral changes. This underlines the importance of interdisciplinary collaboration in dentistry.

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