

## THE IMPACT OF OCCUPATIONAL ACIDS EXPOSURE ON DENTAL EROSION: A REVIEW

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*Aim of review* was to highlight the association between occupational acids exposure and severe dental erosions in high-risk populational groups. The numbers of studies assessing the relationship between various polluting agents and dental pathology is limited, while the role of the occupational acid exposure and dental erosions and wear was extensively researched. Occupational acids exposure is a risk factors for teeth loss by severe dental erosions and wear. Most frequent risky professional environments are associated to hydrochloric, nitric and sulphuric acid. Prevalence of the dental erosions increases with acid concentration and increasing acid exposure time. Long-term workers are high-risk groups for teeth loss due to generalized advanced dental erosions.

*Keywords:* acid exposure, occupational, dental erosions, dental wear.

### INTRODUCTION

While acid mist suspended in the air is linked to various general health problems, also it was identified as a significant risk factor for oral diseases in various previous studies.<sup>1,2</sup> Workers in industries involving acid exposure (hydrochloric acid, nitric acid, sulphuric acid, acetic acid, chromic acid, phosphoric acid) are considered high-risk group for dental erosive wear (pathologic chronic loss of enamel and dentine due to the chemical influence of extrinsic and intrinsic acids without bacterial involvement).<sup>2,3</sup> The onset and severity of dental erosions and wear depend on various parameters such as nutrition, saliva, systemic status, as well as mechanical stress by dental abrasion and attrition. Dental erosions must be differentiated by erosive tooth wear which is a chemical-mechanical process resulting in a cumulative loss of hard dental tissue not caused

by bacteria, and it is characterized by loss of the natural surface morphology and contour of the teeth.<sup>4</sup> Severe erosive tooth wear might also constitute near and frank exposures of the pulp requiring dental treatment or can lead even to complete destruction and tooth loss<sup>5</sup>. Clinical reports indicate that exposure to extrinsic acids, combined with reduced salivary flow, accelerates tooth dissolution, leading to a permanent exchange of ions and substances, causing reorganization within the tooth structure or at its surface, which alters both its strength and composition. The severity and rate of erosion depend on the vulnerability of dental tissues to acidic dissolution, with certain tissues being more prone to erosion than others based on their resistance to breakdown.<sup>6</sup> Patients suffering from early, medium, or severe dental erosions/wear requires both minimal preventive measures and oral rehabilitation including restorations, reconstructions or, in case of tooth

loss, replacement therapies.<sup>7,8</sup> Workers exposed to acidic professional environments are at risk of generalized severe dental erosions, which can significantly impair their oral health and function. Also, they can suffer from various health issues, particularly kidney disease, due to the high levels of dissolved lead in the acid solution. Thus, unexplained symptoms request a medical referral for a comprehensive health assessment.<sup>9</sup> The drawback of the epidemiological studies in this field is the overlooking of individual factors and lifestyle habits that may contribute to the development of dental erosions, while the limited number of controlled studies makes it difficult to draw definitive conclusions for all risk groups.<sup>1</sup> A better understanding of the impact of occupational dental erosion on oral health-related quality of life can motivate both employees and employers to adopt stricter protective measures.<sup>10</sup>

## MATERIALS AND METHOD

We conducted a literature review in PUBMED database, searching for research on the role of acids exposure in professional environment on the pathology of dental erosion and wear.

To find papers focused on the research theme, we used the keywords as follows: (1) “occupational” AND “dental erosion” AND “exposure to acid”; (2) “occupational” AND “dental wear” AND “exposure to acid”; (3) (1) “dental erosion” AND “acid” AND “professional exposure”; (4) “dental wear” AND “acid” AND “professional exposure”. The questions used as references to reach the objectives of this review were inclusion criteria for the selected papers: (1) is there a direct link between “acid” AND “dental erosion”? (2) is there a direct link between “acid” and “dental wear” (3) which population groups are mostly affected by occupational exposure? (4) what type of professional environments are directly linked to dental erosion/wear? After the assessment of the quality and relevance of papers selected from the search, we included

only those considered relevant and answering to the screening questions, while the others were excluded from review (small sampling size, poorly developed analysis).

The PUBMED database returned 39 scientific articles, published between 1964 and 2024, in which we analyzed specific data related to questions used as references, following the use of key terms. Of these, 24 articles, were selected, following verification of the inclusion criteria.

## RESULTS AND DISCUSSIONS

The studies included in our review supplied data related on relationships between type of acids, their concentration, time exposure, and prevalence of dental erosions/wear in workers exposed to acids.

A review of literature data, concluded that occupational acid exposure might increase the risk of dental erosion, within battery and galvanizing workers. In 2007 when this review was published, the conclusion was that data for other professional groups need to be confirmed by further studies.<sup>2</sup> All studies from this review indicate a clear link between prolonged acid exposure and increased dental erosion. Workers in battery factories, galvanizing factories, and zinc plants were consistently found to have significant dental erosion, with the severity increasing with both the duration of exposure and the concentration of acids in the work environment. The studies suggest a need for preventive measures, including improved occupational safety standards and regular dental check-ups for workers exposed to harmful acidic fumes.<sup>11–30</sup>

An early study highlighted the severe dental erosion caused by sulfuric acid exposure in the battery industry. The prevalence of erosion was notably high, particularly in workers exposed for long periods.<sup>11</sup> Another early study focused on sulfuric acid exposure in industrial settings and its effect on dental health, confirming the presence of significant dental erosion among workers.<sup>12</sup> A research group explored dental erosion in industrial settings, with a focus on

workers exposed to acids. It found that long-term exposure led to severe enamel wear, particularly in workers handling sulfuric acid. The research group concluded that industry-specific interventions were needed to protect workers' oral health.<sup>13</sup> A pilot study in a Norwegian zinc factory found a correlation between acid exposure and dental erosion. Workers exposed to sulfuric acid for long durations had significantly higher rates of dental erosion.<sup>14</sup> Workers in a zinc galvanizing plant exposed to hydrochloric acid had high rates of dental erosion.<sup>15</sup> A research group examined the chronic effects of sulfuric acid exposure among lead-acid battery workers, with a particular focus on the respiratory system and teeth. Dental erosion was found to be prevalent among workers.<sup>16</sup> The study of German battery factory workers revealed a high prevalence of dental erosion due to sulfuric acid exposure. The results supported the conclusion that long-term exposure to acidic environments leads to progressive dental erosion, and preventive measures should be taken to safeguard workers' oral health.<sup>17</sup> A research group linked acid fumes in the work environment to an increased prevalence of dental erosion among factory workers. The study conclusion was that more stringent industrial regulations and dental care provisions were needed to prevent enamel degradation in such environments.<sup>18</sup> In a study, workers in environments with high concentrations of organic and inorganic acids had high levels of dental erosion. The study concluded that both environmental control and worker education were essential in mitigating the risks of dental surface loss.<sup>19</sup> A research group study found that workers exposed to sulfuric and other acids had a significantly higher incidence of dental erosion.<sup>20</sup> A research group compared tooth surface loss among factory workers in Finland and Tanzania. Workers exposed to inorganic acid fumes showed significant enamel erosion.<sup>21</sup> A research group found that workers exposed to acidic fumes had higher levels of dental erosion compared to a control group. A percentage of 76% of male metalworkers exhibited dental erosion, with 25% reporting

tooth loss due to acid exposure. There was a 5-times higher risk for dental erosions in strippers working closest to the acid source compared to other workers. No clear relationship was found between acid exposure time and dental erosion.<sup>22</sup> In a comparative cross-sectional study, dental erosion among industrial workers was confirmed as a significant issue, particularly among those exposed to acid fumes. In an electrowinning facility in South Africa, 21% of workers had enamel erosion, and 76% had dentine erosion. Workers exposed to sulfuric acid concentrations of 0.3–1 mg/m<sup>3</sup> had a five-times higher risk of dentine erosion than those exposed to 0.1–0.3 mg/m<sup>3</sup>. Strippers had 3-times higher risk when compared to other acid workers. The findings reinforced the need for regular dental check-ups and occupational health measures to minimize the impact of acidic environments on oral health.<sup>23</sup> A research group found that workers exposed to acid fumes in the phosphate and battery industries in Jordan had significantly higher rates of dental erosion compared to non-exposed workers. A percentage of 76% from workers exposed to acid fumes in phosphate and battery industries experienced some form of dental erosion. Prevalence was notably higher in workers exposed to battery fumes compared to those in the phosphate industry. They concluded that exposure to acid fumes was a major occupational hazard contributing to dental erosion and that preventive measures were essential to mitigate these effects. The most common complaints among workers included dental hypersensitivity and enamel loss, indicating the need for improved protective strategies in these industries.<sup>24</sup> The impact of acid exposure (solution, fumes) was evaluated by a cross-sectional comparative survey performed among battery chargers and automobile mechanics to assess the impact of acid exposure on tooth enamel wear (upper and lower central sextants). The study group included 105 subjects (1100 teeth) were recruited with age from 11 to 68 years. Among the automobile mechanics, 3.2% showed signs of wear, while in the battery charger group, 41% exhibited wear, with significant statistical

differences between them ( $p < 0.05$ ). The battery chargers also had a higher percentage of missing teeth (14.9%) when compared to 11.44% in the automobile mechanics group ( $p > 0.05$ ). The research group highlights that battery chargers face an occupational hazard due to exposure to highly erosive acids and fumes.<sup>25</sup> A research group found a strong association between occupational behaviors and the prevalence of dental erosion, particularly in industries involving acid exposure (hydrochloric acid, nitric acid, sulphuric acid). A percentage of 17% of teeth had enamel erosions while 7% of teeth were diagnosed with dentine erosions. Workers with poor health behaviors, such as neglecting protective measures, had higher rates of erosion. Risk of dental erosion increased with increasing acid exposure time.<sup>26</sup> The objective of a research group was to determine if acetic acid released by silicone sealers during curing increases the risk of dental erosion, posing an occupational hazard. Thirteen workers exposed to silicone for an average of 4.2 years underwent medical and dental evaluations. The results showed significantly higher dental erosion in exposed individuals, with a positive correlation between exposure duration and erosion severity. Additionally, exposed workers reported more upper respiratory issues than controls, indicating a potential occupational risk from acetic acid vapors.<sup>27</sup> A cross-sectional study was conducted with 951 participants from 42 factories using five types of acids (ACs) below the Korean Threshold Limit Values (K-TLVs). Among the participants, 519 were acid-exposed workers, and 431 were non-exposed. Erosion was classified using the modified ten Bruggen Cate's criteria, and exposure details were gathered via questionnaires. Logistic regression analysis revealed that multiple AC exposures were strongly linked to severe erosion, with a significant interaction between mask usage and AC exposure. The research group concluded that exposure to various types of acids, even below K-TLVs, is associated with dental erosion, suggesting that K-TLVs should be lowered.<sup>28</sup> A research group investigated oral health of long-term workers from a lead storage

battery factory with sulfuric acid concentration in exceeding the permissible limit ( $1.0 \text{ mg/m}^3$ ). Dental erosion rates were analyzed by tooth type, years of employment, and sulfuric acid concentration in the work environment. The severity of dental erosions was classified according to a specific diagnostic criterion. Mostly the anterior mandibular teeth were primarily affected, with a prevalence rate of 20%. The incidence of dental erosion increased significantly after 10 years of employment, affecting 42.9% of workers with 10–14 years of service, 57.1% of those with 15–19 years, and 66.7% of those with more than 20 years, with an overall prevalence of 22.5%. The rate of dental erosion also increased in correlation with the sulfuric acid concentration in the air: 17.9% at  $0.5\text{--}1.0 \text{ mg/m}^3$ , 25.0% at  $1.0\text{--}4.0 \text{ mg/m}^3$ , and 50.0% at  $4.0\text{--}8.0 \text{ mg/m}^3$ . This study indicated the need to assess not only the duration of exposure to sulfuric acid but also the concentration of sulfuric acid in the air for long-term workers in environments with acids exceeding average values.<sup>29</sup> A research group aimed to assess the relationship between occupational dental erosion and oral-health related quality of life (OHRQoL) among battery and factory workers in Bengaluru, India. The dental erosion and OHRQoL scores were evaluated in 400 workers. The study group showed a significantly higher prevalence of dental erosion (39.5%) compared to the control group (11.5%), with a strong correlation between erosion severity, time exposure, and lower OHRQoL scores. Occupational dental erosion significantly affects OHRQoL, highlighting the need for improved workplace safety measures.<sup>10</sup> A recent study evaluated 309 participants from four acidic solution factories (157 control, 152 exposed) that underwent oral examinations and completed a questionnaire, including the DMFT index, CPI, LA index, and tooth erosion assessment. Multivariate logistic regression showed that acid exposure was significantly associated with periodontal health, specifically loss of attachment (LA) (OR= 2.32, 95% CI 1.03–5.26), but not with tooth erosion, DMFT, or CPITN.<sup>1</sup> The study included 90 battery factory workers (62 males, 28 females)

and recorded demographic data on age, gender, and length of exposure. Dental erosion was assessed using the Smith and Knight tooth wear index. Statistical analysis showed 43.3% of workers had dental erosion, with a higher prevalence in females (54%) compared to males (38.7%). Among those affected, 66.6% had mild erosion (score 1), while 33.4% had moderate to severe erosion (scores 2 and 3). Longer employment duration (>11 years) was significantly associated with more severe erosion. The research group concluded that dental erosion is prevalent among battery factory workers, highlighting the need for protective measures and workplace monitoring.<sup>1</sup> The numbers of studies assessing the relationship between various polluting agents and dental pathology is limited, while the role of the occupational acid exposure and dental erosions and wear was extensively researched. Occupational acids exposure is a risk factors for teeth loss by severe dental erosions. Most frequent risky professional environments are associated to hydrochloric, nitric and sulphuric acid. Prevalence of dental erosions increases with acid concentration and increasing acid exposure time. Long-term workers are high-risk groups for teeth loss by severe generalized dental erosions.

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