

# Erosive tooth wear – a review on global prevalence and on its prevalence in risk groups

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## Key points

Provides an overview on the prevalence of erosion on a global scale.

Discusses prevalence of erosive tooth wear in risk groups.

Discusses prevalence of erosion in different age groups.

Erosion is a common phenomenon in the general population of developed countries. However, due to variations in indices, sample sizes and general study designs, it is difficult to compare the various studies and to estimate actual global prevalence. Therefore, the aim of this present paper is to give a narrative overview on the data available on the global prevalence of erosion. Information on prevalence is not available from each country; in particular, data from Asia, Africa, South America, North America and large parts of South-Eastern Europe are unavailable. There is a large variation in global prevalence ranging between 0 and 100%. Calculating a rough mean from the data available, a mean prevalence in deciduous teeth between 30% and 50% and in permanent teeth between 20% and 45% can be estimated. There seems to be a gender difference and an increase in prevalence with age. Prevalence studies on erosion risk groups show comparable variation. Only in patients with gastro-oesophageal reflux disease (GORD) and eating disorders associated with vomiting can a clear impact on erosion prevalence be found. In people who consume acidic foods and drinks, a higher risk can be found for some specific comestibles. However, there is a lack of controlled epidemiological studies, making it difficult to generalise. There is a clear need for well-designed studies on this issue.

## Introduction

It is often said in the public media that dental erosion is a common condition in the general population and is becoming more and more prevalent. However, a discussion regarding the prevalence of dental erosion is not as simple as it may seem.

The number of studies published per decade has increased over time (Fig. 1). A PubMed search revealed a total of 931 publications using the terms '(tooth wear OR dental erosion) AND prevalence'. However, the major problem in the estimation of erosion prevalence is that comparison of the various publications and studies is difficult. There is a

large variation in indices (for a small selection of erosion indices available see Table 1), sample size and type of recording (number of recorded teeth, clinical recording vs. recording based on photographs or models). In addition, the choice of the reference value (individual, teeth or tooth side), the choice of study population (age and dentition, risk groups, general population), standards (calibration procedures, appropriateness of indices used, study design in general) and choice of outcome (yes/no decision, shape of lesion, estimation of severity, quantification of dimension of tissue loss) does not seem to be standardised. In particular the choice of index has an impact on the study outcome and might be one determinant of the dimension of erosion prevalence.<sup>1</sup> In addition, different countries and even different regions within one country have different diets and preferences in taste, as well as customs and behaviours. All these factors can lead to variations in the prevalence of erosion.

An overview on erosion prevalence in various age and risk groups is given, independent of

the index used. Only data based on individual recordings are presented, meaning that a case is recognised as erosion-positive if one lesion is present in any form in the oral cavity.

The narrative review is based on previous reviews on erosion prevalence<sup>2,3</sup> and on a PubMed search with the following search terms: 'dental erosion AND prevalence', 'tooth erosion AND prevalence', 'erosive tooth wear AND prevalence', 'dental erosion AND severity', 'tooth erosion AND severity', 'erosive tooth wear AND severity', 'dental erosion AND incidence', 'tooth erosion AND incidence', and 'erosive tooth wear AND incidence'.

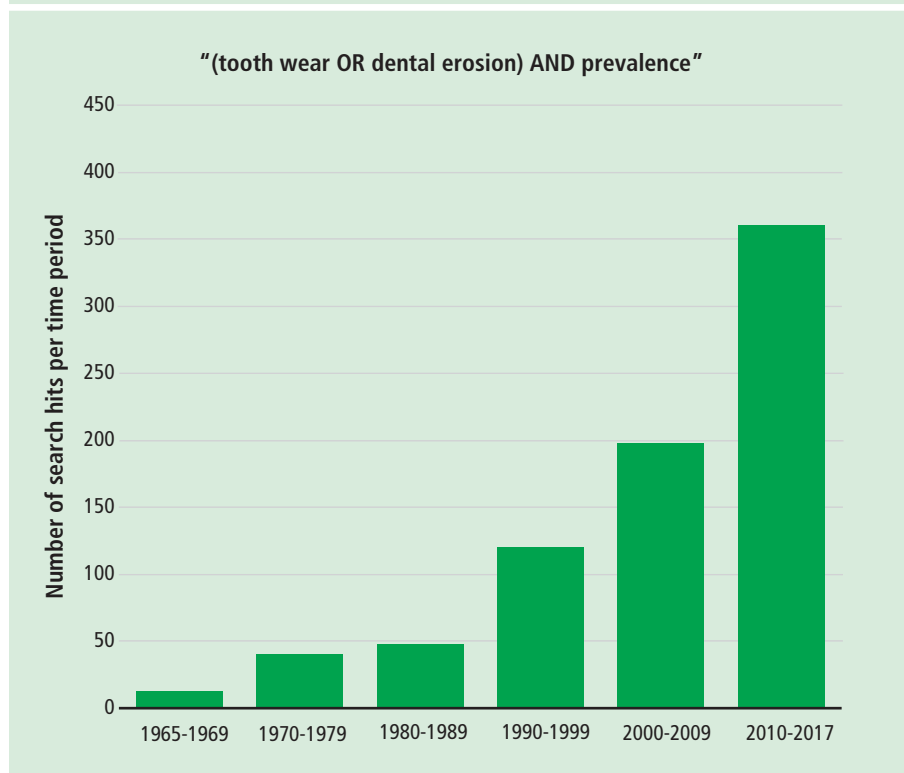
## Erosion prevalence in the general population

Studies on erosion in children and adolescents and on adults exist. The number of studies on children and adolescents (age between 2 and 17 years) is greater than those on adults, probably due to the easier accessibility of children for surveys in kindergartens, schools or other public institutions.

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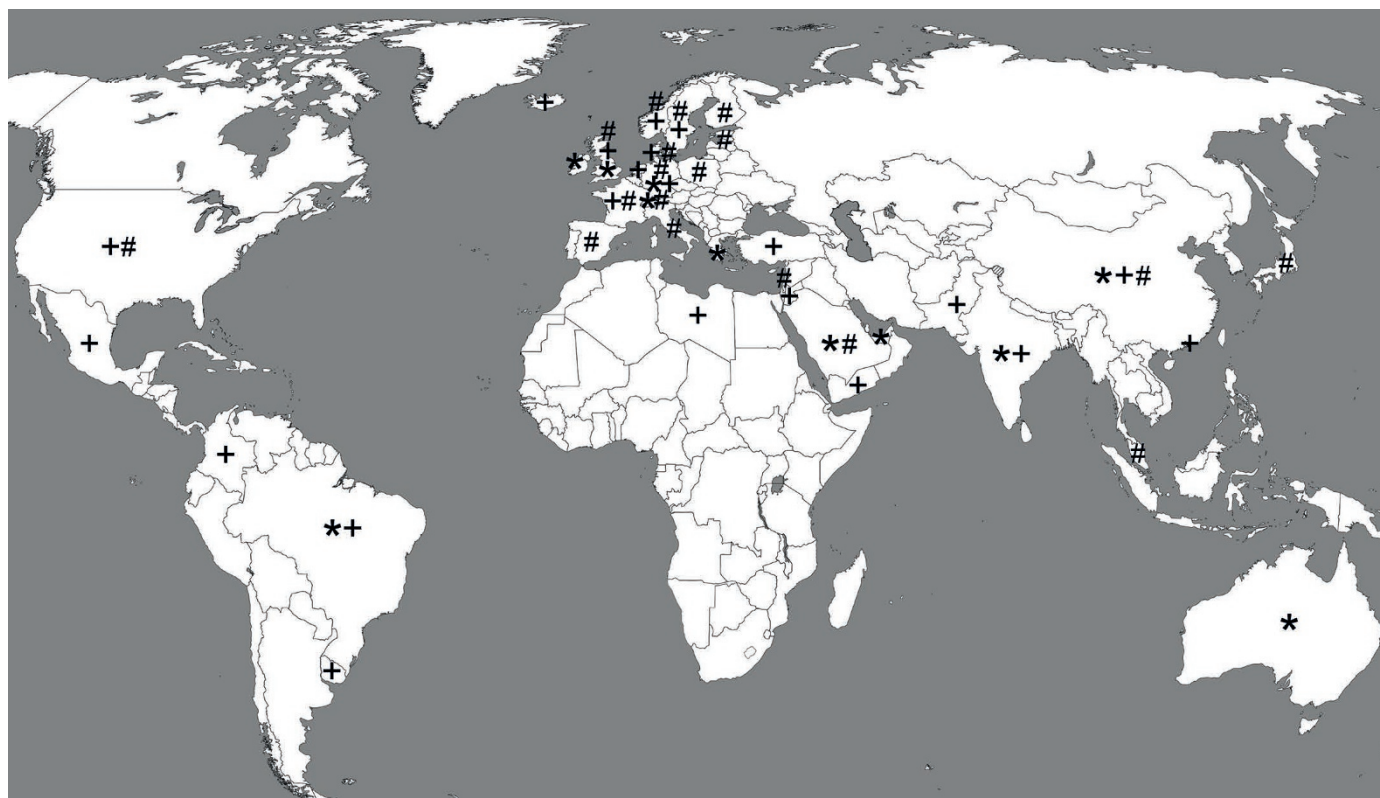
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**Fig. 1** Results of the PubMed search with the terms (tooth wear OR dental erosion) AND prevalence. First publications were found in the year 1965. There is a distinct increase of publications dealing with prevalence of tooth wear in general and of dental erosion over time



Even if numerous studies on erosion prevalence in children and adolescents have been published, there is still no comprehensive knowledge on prevalence in this age group on a global level (Fig. 2). It is well accepted that the mechanical resistance of deciduous teeth is lower than that of permanent teeth, however, there is no consensus on whether deciduous teeth are more susceptible to erosion.<sup>4-8</sup> As a consequence, it is not clear what has actually been classified in the studies: erosion, erosion/abrasion, abrasion, attrition or tooth wear. Nevertheless, the following data is given as presented by the authors of the studies as erosive or erosive-abrasive defects.

Only selective information from isolated countries exists on erosion prevalence in deciduous teeth and shows a wide span, even within one country, between 0% and 100% (Australia 0–33%,<sup>9</sup> Brazil 1–62%,<sup>10-13</sup> China 6–15%,<sup>14,15</sup> Germany 32–71%,<sup>16-18</sup> Great Britain 28–50%,<sup>19,20</sup> Greece 52–79%,<sup>21</sup> India 29%,<sup>22</sup> Ireland 47%,<sup>23</sup> Saudi-Arabia 31%,<sup>24</sup> Switzerland 100%,<sup>25</sup> and United Arab Emirates 59%<sup>26</sup>). Estimating a rough mean of all these data shows that the global prevalence of erosion is between 30% and 50%, with some single outliers on the lower (Australia, China) and higher ends



**Fig. 2** The world map shows the availability of global erosion prevalence data from the general population (\* children, deciduous teeth; + children and adolescents, permanent teeth; # adults). Data are available from countries all over the world, however, systematic information from Asia, North America (except USA) and South America (except Brazil), South Eastern Europe as well as Africa is rare or even not available, meaning that there is a need for good studies from the other countries

**Table 1** Small selection of indices available for estimation of erosion

Index	Target group	Rough description	Refs
Eccles-Index	Adults	Classification according to site and severity	151
Tooth Wear Index (TWI)	Adults	Not a proper erosion index, but often used, classification according to site and severity, more detailed than Eccles	152
Modified TWI	Children	See TWI	20
Linkosalo and Markkanen	Children and adults	Index comparable to TWI and Eccles-Index	132
O'Brien Index	Children	Partial recording system—modified TWI	153
Lussi Index	Children and adults	Classification according to site, dentine exposure and dimension of exposure	154
O'Sullivan Index	Children	Classification according to site and severity	155
Simplified Tooth Wear Index (STWI)	Children and adults	Only dentine defects are recorded – dimension of dentine exposure	49
Basic Erosive Wear Examination (BEWE)	Children and adults	Size of defects independent of dentine exposure	156
Exact Tooth Wear Index	Adults	Detailed index on dimension of wear in enamel and dentine	157
Visual Erosion Dental Examination (VEDE)	Adults	Modification of STWI and TWI	158
Evaluating Index of Dental Erosion (EVIDE)	Children and adults	Classification according to presence of defects (yes/no) and whether dentine is involved (yes/no)	159

(Greece, Switzerland). The severity of erosion differed between the various studies; in some studies, erosion was confined to enamel in most cases (>80% of erosion cases),<sup>10,14,16,26</sup> whereas other studies show dentine involvement in 21%<sup>23</sup> to 48%,<sup>25,27</sup> and pulp involvement is rare with a prevalence below 1%.<sup>14,27</sup> With regard to localisation, erosion in deciduous teeth occurs most often on the maxillary incisors<sup>16,21,27</sup> as well as at the occlusal surfaces of the lower molars.<sup>11,17,21,25,27–29</sup>

With regard to permanent dentition in children and adolescents, an overview subsumed the studies found in the literature. The overview showed a mean erosion prevalence in America of about 21%, 22% in Europe, 20% in Asia and 41% in the Middle East and Africa.<sup>1</sup> These figures suggest that the data for permanent dentition are more homogeneous than for primary dentition. However, a detailed review of the literature revealed the same data for permanent dentition and for primary dentition (Fig. 2). The prevalence had a wider range, even within one country, between 0 and 97% (Brazil 7–25%,<sup>28,30–34</sup> China 19–89%,<sup>35,36</sup> Columbia 53%,<sup>37</sup> Denmark 14%,<sup>38</sup> France 57%,<sup>39</sup> Germany 4–12%,<sup>17,40</sup> Great Britain 12–100%,<sup>41–49</sup> Hong Kong 75%,<sup>50</sup> Iceland 0–31%,<sup>51,52</sup> India 9%,<sup>53</sup> Jordan 32–51%,<sup>54,55</sup> Libya 41%,<sup>56</sup> Mexico 32%,<sup>57</sup> Norway 59%,<sup>58</sup> Pakistan 46%,<sup>59</sup> Sweden 16%,<sup>60</sup> The Netherlands 3–44%,<sup>61–64</sup> Turkey 28–53%,<sup>65,66</sup> Uruguay 53%,<sup>67</sup> USA 41–46%,<sup>42,68</sup> and Yemen 85–97%<sup>69</sup>). Most of the recordings were made clinically, except for the studies by Ganss *et al.*<sup>17</sup> and Chadwick *et al.*,<sup>43</sup> which were made on models and replica, respectively. Whether or

not dentine was involved was not recorded for all studies and in general, dentine erosion in permanent dentition was less frequent than in primary dentition, with a prevalence ranging between 2% and 30%.<sup>44–46,51,56–58,69</sup> Erosion was mostly located on the occlusal surfaces of the first mandibular molars<sup>17,46,52,57,63,64</sup> or on the palatal surfaces of the upper anterior teeth.<sup>38,46,52,63–65</sup>

Some studies have reported that the prevalence of erosion is age-dependent (primary dentition: Australia: 2 yr 0%, 3 yr 7%, 4 yr 33%,<sup>9</sup> Germany 2–3 yr 14%, 4y 33%, 5 yr 59%, 6–7 yr 72%;<sup>18</sup> permanent dentition: Iceland 6 yr 0%, 12 yr 16%, 15 yr 31%;<sup>52</sup> The Netherlands 11 yr 30%, 12 yr 38%, 13 yr 41%, 14 yr 43%, 15 yr 44%;<sup>63</sup> The Netherlands 10–13 yr 3%, 15–16 yr 30%;<sup>64</sup> Sweden 13–14 yr 12%, 18–19 yr 22%;<sup>60</sup> Mexico 14–16 yr 17%, 17–19 yr 30%<sup>57</sup>). An increase in erosion prevalence over time (from the past to the present) was also investigated by some studies, and they showed a clear increase over the last few decades.<sup>17,18</sup>

No clear statement can be made as to whether female or male children or adolescents are more affected by erosion. While some studies observed no association with gender,<sup>11,30,33,66</sup> others reported a higher prevalence in females<sup>22,69</sup> or in males.<sup>15,18,34,37,46,59,60</sup> However, it seems to be a general trend that males are more affected by erosion than females.

Similar to erosion prevalence data in children and adolescents, only selective data on erosion prevalence in adults are available (Fig. 2), showing the same variation, ranging between 2 and

100% (China 44%,<sup>70</sup> Denmark 2%,<sup>71</sup> Finland 18–75%,<sup>72,73</sup> France 26%,<sup>73</sup> Germany 24–40%,<sup>40,74</sup> Great Britain 3–100%,<sup>73,75,76</sup> Israel 37–62%,<sup>77</sup> Italy 21%,<sup>73</sup> Japan 26%,<sup>78</sup> Latvia/Estonia 18%,<sup>73</sup> Malaysia 68%,<sup>79</sup> Norway 20–38%,<sup>80,81</sup> Poland 42%,<sup>82</sup> Saudi Arabia 28%,<sup>83</sup> Spain 26%,<sup>73</sup> Sweden 75%,<sup>84</sup> Switzerland 8–82%,<sup>85–88</sup> and USA 25%<sup>89</sup>). The values shown are mostly the results of localised studies; data for countrywide surveys on erosion prevalence are only available from a few countries, such as Denmark, Finland, Germany, Great Britain, Poland, and USA. The prevalence of erosion in permanent dentition in adults with a rough mean is estimated to be between 20% and 45%, with some outliers at the lower (Denmark) and the higher ends (Malaysia, Sweden).

Dentine involvement was found in 2% to 45% of cases and mostly involved the occlusal surfaces. Erosive defects were mostly located on the occlusal surfaces of the first molars, both in the upper and lower jaws and on the palatal surfaces of the upper front teeth.<sup>86,87</sup> An age-dependent increase of erosion prevalence was not found in all studies. In the study published by Smith and Robb, the prevalence was very low and more or less stable (15–26 yr 6%, 26–55 yr 4%, 56–66 yr 8%, >65 yr 9%).<sup>76</sup> The same result was found in the Danish Health Examination Survey 2007–2008.<sup>71</sup> In contrast, the fifth German Oral Health Survey (DMS V) found a clear relationship between increasing age and increasing erosion prevalence (12 yr 4%, 35–44 yr 24%, 65–74 yr 40%).<sup>40</sup> Comparable results were found by Vered *et al.* in Israel (15–18 yr 37%, 25–28 yr

42%, 35–38 yr 56%, 45–48 yr 53%, 55–60 yr 62%).<sup>77</sup> Differences in gender were only investigated in some studies, with a slightly higher prevalence in males being reported.<sup>72,80</sup>

### Erosion prevalence in risk groups

According to the aetiology of dental erosion, which refers to exogenous and endogenous acid sources, risk groups for the development of dental erosion can be identified. Not every person who is exposed to acids, both from exogenous and endogenous sources, will develop erosion but the regular exposure of teeth to different types of acids increases the risk for the development of erosive defects. The sole endogenous acid source is gastric juice. It can reach the oral cavity during vomiting or reflux episodes. Both are often associated with erosive defects, if occurring frequently.<sup>90</sup> Sources of exogenous acids are more manifold. Special diets and the regular frequent consumption of acidic drinks and foods are regarded to be the major cause of erosion.<sup>91</sup> In addition to nutritional factors, regular occupational exposure to acids, as well as several medications and the abuse of drugs and alcohol might be relevant.<sup>3</sup> Even though it is chemically and biologically plausible that the previously described acid sources can cause erosion,<sup>92</sup> a clear association between acid exposure and the occurrence of erosion cannot be found for all evaluated sources. Therefore, we aimed to describe whether regular exposure to different acid sources has an actual impact on erosion prevalence and severity. In order to get an idea of the global distribution, the data will be presented according to countries in most cases, similar to the presentation of data from the general population.

### Gastro-oesophageal reflux disease

A single episode of reflux of acid into the oral cavity does not lead to a pathological condition. However, if reflux episodes occur regularly over a long period, this is defined as gastro-oesophageal reflux disease (British English: GORD, American English: GERD), and the risk of developing erosions increases. GORD can be symptomatic<sup>93</sup> or asymptomatic<sup>94</sup> and a 2014 systematic review demonstrated that the prevalence of GORD in the general population ranged from 18.1% to 27.8% in North America, 8.8% to 25.9% in Europe, 2.5% to 7.8% in East Asia, 8.7% to 33.1% in the Middle East, 11.6% in Australia, and 23.0% in South America.<sup>95</sup> Both forms can potentially affect the dental hard tissue and increase the risk for developing erosions.<sup>96</sup> The number of controlled studies is

limited both for children and adults, and most of them have a small number of cases. In both age groups, the prevalence again had a wide range between 11–98% and 14–75%, respectively, which can only be explained in part by the prevalence of the underlying disease GORD.

Prevalence values (cases/controls) for children were as follows: Australia 46/40%,<sup>97</sup> Great Britain 11/14%,<sup>98</sup> 79/62%,<sup>99</sup> Iran 98/19%,<sup>100</sup> Turkey 76/24%,<sup>101</sup> and USA 85/75%.<sup>102</sup> The uncontrolled studies had values between 17% and 87%.<sup>103–106</sup> Prevalence for the adults were as follows: China 49/14%,<sup>107</sup> 61/28%,<sup>108</sup> Iceland 35/40%,<sup>109</sup> Italy 9/13%,<sup>110</sup> Iran 23/7%,<sup>111</sup> Japan 24/0%,<sup>112</sup> Mexico 79/3%,<sup>113</sup> Nigeria 16/5%,<sup>114</sup> Norway 49/35%,<sup>80</sup> Romania 35/13%,<sup>115</sup> Spain 48/13%,<sup>116</sup> and USA 75/17%.<sup>117</sup> Prevalence values between 6 and 24%<sup>118,119</sup> were found in the uncontrolled studies. As displayed, not all studies showed a higher prevalence in the case group compared to the control group. However, upon closer evaluation of the data in most of these studies, the defects are mostly more severe in cases of GORD compared to the control cases.<sup>3</sup>

### Eating disorders

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) eating disorders are roughly divided into anorexia nervosa (AN), bulimia nervosa (BN) and eating disorders not otherwise specified (EDNOS). AN and BN can occur separately, but can also occur simultaneously. Both forms can potentially increase the risk for dental erosion, since they affect the regulation of food intake, such as restricted dietary choices, and induced vomiting. The prevalence of eating disorders (AN and BN) in developed countries ranges between 1% and 5%<sup>120</sup> and mostly in younger women between the ages of 13 and the mid-30s. Information on erosion prevalence due to eating disorders is only available from a few countries; for most of these countries, there was no control or comparison group. For AN, none to a slight increase in risk for development was reported,<sup>121</sup> whereas for BN, the risk for erosion dramatically increased (odds ratio (OR) of 7<sup>121</sup> or higher<sup>122</sup>). Therefore the reported prevalence of erosive tooth wear only for BN is as follows: Brazil 45%,<sup>123</sup> Finland 63%,<sup>124</sup> Great Britain 42%,<sup>125</sup> Israel 42%,<sup>126</sup> Japan 86%,<sup>127</sup> Norway 70%<sup>128</sup> and Sweden 98%.<sup>129</sup> Eating disorders in combination with vomiting are associated with an increased occurrence, severity and risk of dental erosion.

### Special diet

Special diets, especially those rich in fruits and other acidic foods, can increase the risk of dental erosion. Approximately 1–9% of the western population is vegetarian<sup>130</sup> and 0.1% lives on a vegan diet.<sup>131</sup> Even if it is plausible that a vegetarian or vegan diet may increase the risk for erosion, only two studies have shown an increase of erosion prevalence for those eating a vegetarian diet (cases/controls: Finland 77/0%<sup>132</sup> and Germany 25/13%<sup>133</sup>) and two others an increased risk (Trinidad OR up to 6.7<sup>134,135</sup>). In all other studies, no difference between cases and controls was found.<sup>136–138</sup> Another special form of diet is a raw food diet, which includes only non-processed food. This type of food ingestion has only a slight (yet significant) impact on erosion prevalence (Germany 98% in cases vs 87% in controls), likely due to the high prevalence in the control group. However, a clear impact on the severity of erosion was found in this study.<sup>139</sup>

### Acidic beverages

One of the most frequent exposures to acids is the regular consumption of acidic drinks. Only association but no prevalence studies exist on this issue. It is well known that habits such as high frequency of consumption, swishing, sipping or holding beverages in the mouth increase the risk for developing erosions.<sup>64</sup> Due to large differences in methodological processes (indices for assessment of erosion, questionnaires for collecting data on nutritional behaviour, sample size etc) a comparison between studies is difficult. Furthermore, a major factor is the choice of study population. Some studies include only those persons showing erosion or even severe erosion. In these cases, an association with all types of ingested food will be found, even to typical non-erosive food such as milk or yoghurt. Others found no association with any type of food or drinks.<sup>3</sup>

A systematic review and meta-regression analysis showed that there is a clear difference between the various continents in the risk for developing erosion.<sup>1</sup> In particular, in the Middle East and Africa, where the consumption of acidic beverages and acidic food might be common, the risk for the development of erosions is particularly high (OR of 4.5 and 24.5 respectively). Asia also has a very high OR for consumption of natural fruits (13.4) and acidic food (4.4), while for America as



well as Europe, the risk values for consumption of acidic food in any form ranges between 0.86 and 1.61.<sup>1</sup>

## Drugs and alcohol disorders

It is often speculated that the consumption of illicit drugs is associated with erosive tooth wear. Indeed, destruction of the dental hard tissue can be found commonly in drug-dependent persons, however, mostly carious or attritional defects due to changes in muscular activity are found.<sup>140,141</sup> The regular abusive consumption of alcohol ranges between 9–13% in developed countries and is a relatively common phenomenon. Often, dependence is associated with regular vomiting or reflux, increasing the risk for erosive defects. Only few studies deal with this issue and have contradictory results. However, there seems to be a trend for increased prevalence and severity of erosion in persons consuming large amounts of alcohol.<sup>3</sup>

## Legal drugs and medications

With regard to the prevalence of erosion due to the intake of drugs and medications, little information exists. Mostly, case reports or anecdotal reports are published. In theory, acidic active agents such as acetylic salicylic acid or acidic formulations of vitamins or iron preparations could lead to erosion. However, the contact time to the dental hard tissue would only be long enough for a defect to occur, if the preparations are regularly taken as chewable or effervescent tablets.<sup>142</sup> Asthma medications (beta-sympatho-mimetics) are sometimes acidic preparations. In theory, asthma medications have the potential to change the salivary flow rate and are associated with a higher prevalence of some types of gastric reflux.<sup>143</sup> Results of studies on this issue appear slightly inconclusive: there seems to be no effect on erosion prevalence,<sup>3</sup> but erosion severity might be increased.<sup>144</sup>

## Occupation and sports

In cases of regular contact to environmental or occupational acids, erosive defects can occur. If no occupational safety measures are used, the risk for erosion increases dramatically, as shown in several reviews.<sup>3,145</sup> However, if safety measures are used, the risk can be decreased, and nearly no differences compared to the general population can be found. Wine

tasters cannot use any occupational safety measures and are, therefore, at high risk for dental erosion (OR up to 2.5).<sup>146</sup> In the sole controlled study on this issue from Norway, indeed a higher prevalence than in the control group was found (50/20%).<sup>81</sup>

Professional athletes and swimmers might also have a higher risk for dental erosion due to regular consumption of sports drinks or due to exposure to swimming pool water. A systematic review on the oral health of athletes reports prevalence values between 36% and 86%.<sup>147</sup> Single studies on swimmers found values between 13% and 50%.<sup>148–150</sup> It is often stated that poorly buffered swimming pool water might cause erosion among swimmers. Most swimming pools are well-buffered and pose no risk for erosion. In the case of poorly buffered water only the regular but not occasional exposure carries any risk for erosion.

## Conclusion

There is a tremendous variation in the prevalence data on dental erosion in the general population, both for deciduous and permanent teeth. The reasons for this variation are manifold. On the one hand, the customs and habits differ between different countries. On the other hand, this might be a consequence of the high variation in indices or study designs. In particular, small studies might over- or underestimate the prevalence, as there is a lack of representativeness. Roughly estimated, the prevalence in deciduous teeth ranges between 30% and 50%; in both children/adolescents and adults, the prevalence in permanent teeth ranges between 20% and 45%. There seems to be a trend towards a higher prevalence of erosion in males than in females. In addition, erosion seems to increase with age, shown in several but not in all studies. Isolated studies show also an increase in prevalence over the last few decades.

For risk groups, a high variation in erosion prevalence was also found. The sample size in most studies was smaller than in those on the general population. In patients with GORD and eating disorders in combination with vomiting, erosion seems to be more common than in the general population; in particular, the severity of the lesions is increased in those patients. There is no clear association between special diets and erosion, even if the consumption of acidic food can increase the risk for developing dental erosion.

There is a lack of information on erosion prevalence from large parts of the world.

Therefore, for both the general population and for risk groups, there is a need for well-designed studies including a sufficient number of participants.

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