A Global Compendium of Oral Health

Tooth Eruption and Hard Dental Tissue Anomalies

Edited by Morenike Oluwatoyin Folayan

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Cambridge Scholars Publishing

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This book first published 2019

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-3691-2
ISBN (13): 978-1-5275-3691-3

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FOREWORD

Just as oral health lacks attention as a key aspect of child welfare around the globe, better recognition is also needed about the importance of dental pathobiology for our understanding of child oral health. This book brings together a global perspective on two pressing issues – anomalies of tooth development and tooth eruption – both uniquely and not a moment too soon. If children's oral health is to be improved worldwide as I'm sure we'd all like, international collaborative efforts exemplified by this book will be pivotal to gaining necessary understanding.

My viewpoint has been shaped over the past decade while establishing a global research and education network focussed on tooth development anomalies, which we refer to as "D3s" (being short for developmental dental defects, or DDDs). Through this network (*The D3 Group*), I've had the pleasure of meeting the editor and several other authors of this book. In all cases I encountered an immediate empathy regarding the "D3 problem" – by which I mean not only the clinical conditions themselves, but also the widespread ignorance about D3s across the healthcare sector and an allied lack of research-based understanding. My initial focus coming from a career in biomedical research was on D3 prevention – that is, What research needs to be done if we're to understand the causes and implement appropriate interventions? Recognizing a major gap in understanding, we embarked on a biochemical investigation of demarcated enamel opacities (being the commonest type of D3 and the defining pathology of Molar Hypomineralization). Our findings provided novel clues about pathogenesis and so opened up an exciting new avenue of etiological investigation. It soon transpired however that education and advocacy were even stronger priorities – for instance, Who would fund major research if the global need for it wasn't clear, and how could research outcomes be "translated" into public good given widespread deficits at healthcare policy and delivery levels? Consequently, *The D3 Group* was launched as a "cross-sector" initiative spanning key stakeholders from academia through healthcare providers to industry and public consumers. This bold mission brought many challenges, not least the need to communicate amongst disparate parties and to make a competitive case for research. We soon learned the importance of gathering opinions from far and wide, and also from "small fry" as well as (supposedly expert) "big fish". Moreover, anecdote was switched from something I'd rejected in my career as a scientist to being a valuable library for conceptualization. Such holistic collaborations spurred the development of a translational terminology for D3s framed around the public-friendly concept of "chalky teeth". Likewise, we cultivated a socioeconomic argument for research leveraging the stunning but underrated connection between childhood tooth decay and Molar Hypomineralization ("chalky molars"). Having established a working formula across home ground (Australia and New Zealand), *The D3 Group* and its *Chalky Teeth Campaign* were recently opened to international membership and today our "D3 family" has members in 33 other countries. Which takes me back to this book that coincidentally has a similarly diverse international representation.

The compendium provides a comprehensive and well-structured tour of current thinking about tooth eruption and D3s – that is, an impressive 30 chapters dedicated to country-specific perspectives are sandwiched between 5 chapters of generalized introduction and future aspirations. Through this amalgamation, readers will see not just consensus commonalities but also the diversity of country-specific nuances, all of which provides inspiration for research hypotheses and new initiatives to improve healthcare. Importantly, voice is given to several lower-income countries that, despite having at least the same needs as others, are often at risk of being sidelined from research and product-development considerations. This information will be useful for a broad audience including dentistry, medicine, anthropology, evolutionary biology and forensic science. It will be no surprise that the authorship comprises an impressive multi-ethnic raft of academic clinicians and scientists from around the globe, aptly honoring the ubiquity of the problems under consideration. To have assembled such a collective is testament to the networking skills and academic prowess of the editor Morenike Folayan, whose vast publication record includes several impressive studies of Molar Hypomineralization in Nigeria. Being less familiar with the tooth-eruption side of things, a notable eye-opener for me was learning about the diversity of tooth-emergence patterns in different races, with African and Japanese teeth erupting particularly early and late, respectively. Such diversity has immediate practical impacts for age estimation (as routinely done in orthodontics and forensically) as discussed and, I venture, may also hold etiological ramifications for many D3s.

In conclusion, I admire this book both for its important topic and the internationalized collaborative approach taken to address it. The content comprises an unprecedented set of data and expert viewpoints, the latter clearly sharpened by cross-learning accrued during the networked writing process. So, although a cliché, I think this compendium is a great example of the whole being greater than the sum of its parts. If we (as researchers, healthcare providers and policy makers) aim high to improve child oral health substantially, and preferably through prevention, more of such international collaboration and think-tanking will be needed. Hopefully this book will inspire others to follow suit.

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Introduction to Tooth Eruption, Tooth Emergence and Developmental Dental Hard-Tissue Anomalies

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Introduction

Tooth eruption is a complex and dynamic process that involves the timely action and interaction of cells – osteoclasts and osteoblasts – of the dental enamel organ, follicle, and alveolus (Suri et al., 2004). It is the axial movement of a tooth from its non-functional position in the bone to functional occlusion. Eruption movement occurs in a three-dimensional space, with varying speed, and emerges into a functional position defined by heritable patterns (Marks and Schroeder, 1996). Eruption movement leads to tooth emergence – the time of tooth penetration of the overlying gingiva and its appearance in the oral cavity.

Many animal studies have helped in understanding some of the complex and dynamic processes involved in tooth eruption and emergence. Tooth formation commences with the formation of the mandible and maxilla from the neural crest cells that migrate from various areas on the neural crest of the neural tube. The cells have different molecular origins and different innervations (Kjaer, 2012). Tooth formation then starts from an ectodermal epithelial bud surrounded by regionally specific

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ectomesenchyme in the jaw, referred to as the early tooth primordium (Kjaer, 1998). The odontogenic potential of the epithelium is transferred to the ectomesenchyme (Jussila and Thesleff, 2012) through interaction between the epithelium and the ectomesenchyme, leading to the formation of dental papillae in nonodontogenic, neural crest-derived mesenchymal cells (Mina and Kollar, 1987). The ectomesenchyme in the incisor region, however, differs from that of the molar region (Jussila and Thesleff, 2012), and Wise et al. (2001) cautioned against comparing the rat incisor with the human incisor. There is also a complex process of innervation of the early tooth primordium, which undergoes rapid development, starting from the apical part of the primordium (Kjaer and Nolting, 2008).

Bmp4, Fgf3 and Fgf4 are essential for tooth morphogenesis. The Fgfr2b-mediated epithelial-mesenchymal interaction coordinates tooth morphogenesis and the primordium innervation – dental trigeminal axon patterning with neuroendocrine cells found in the dental epithelium (Kettunen et al., 2007). When axon patterning is defective, there may be the histological absence of the mesenchymal dental follicle, absence of the Tgfβ1, which controls the adjacent Semaphorin 3A-free dental follicle target field, and down regulation of the Sema3A in the dental mesenchyme (Kettunen et al., 2007). Also, the epithelial primary enamel knot fails to express Bmp4, Fgf3 and Fgf4. The importance of tooth innervation in tooth eruption had been demonstrated; when the nerve connection to the teeth is interrupted, eruption stops (Fujiyama et al., 2004).

The critical role of the dental follicle in defining the eruption pathway by bone resorption and alveolar bone formation has been established through multiple animal studies (Marks and Cahill, 1987). Colony-stimulating factor-1, expressed in the dental follicle of erupting teeth, down regulates osteoprotegerin, which is needed for tooth eruption (Wise et al., 2005). Tooth eruption, therefore, depends largely on the signals generated by the dental follicle, which are often inherited patterns. When the epithelium of the crown follicle is inefficient and incapable of initiating resorption of the overlying hard tissue, tooth eruption is arrested (Kjaer, 2014). Tooth eruption is further modulated by the local conditions under which teeth are moved (Kjær, 2014). For example, the quality of the bone tissue surrounding the tooth and factors affecting growth will affect tooth eruption (Helfrich, 2005; Wise et al., 2011).

Factors that affect tooth eruption and emergence

Human studies on tooth eruption and the emergence pattern have been largely limited to clinical and radiographic studies. There is a strong correlation between eruption time and dental maturity: the teeth usually erupt when two-thirds of the tooth-length formation is completed (Haavikko, 1970). There are very few studies showing factors that affect tooth maturation. Yet, the correlation between chronological age and eruption time is weak indicating that the paths for tooth maturation and tooth eruption differ (Kjær, 2014).

The eruption of each of the primary and permanent teeth into the oral cavity occurs over a broad age range. Yet, within this emergence time, there is a significant concurrence on the emergence of individual teeth on either side of the jaw (Wedl et al., 2005) and concurrence on the time of emergence of groups of morphologically similar teeth. The correlation of the time of tooth emergence was reported as higher within tooth groups (incisors, canines and premolars, and molars) than between the groups (Kjær, 2014). While the first permanent molar erupts at about the same time as the central incisors, the eruptions of these two different groups of teeth are not interrelated (Parner et al., 2002).

Genetics, hormonal factors, gender, ethnicity, nutrition and growth parameters, craniofacial morphology, body height and weight are also determining factors for tooth movement from early root formation until teeth appear in the mouth (Kochhar and Richardson, 1998). Also, normal eruption is determined by racial, ethnic, sexual, and individual differences. Liu et al. (1999) reported that heritability is higher for tooth development than for tooth eruption.

Friedlaender and Bailt (1969) reported that Melanesians had an earlier emergence of permanent teeth than European and Asian populations and had a later emergence than African populations. Studies on African population groups have also shown that the teeth of African children emerge earlier than the teeth of Caucasians and Asians. Olze et al. (2007) compared the timing of emergence of a wisdom tooth among Germans, Japanese, and black South Africans and found that emergence was earliest for black South Africans and latest for Japanese. Even within the same population, there are differences: Warren et al. (2017) reported that American Indian children had earlier emergence times of primary teeth than black and white children.

A few studies have reported a relationship between the time of tooth emergence and the weight and height of children, although not all studies concurred. Children who are below average weight and height have later emergence times than those who are within the standard range (Billewicz, 1975). Khan et al. (2011) reported that tall children had delayed tooth emergence irrespective of their weight, while heavy and short children had early emergence. Kutesa et al. (2013), on the other hand, reported that the height of the child had no influence on tooth emergence times, while the influence of weight on tooth emergence times was non-conclusive.

Recent studies have found differences in relationships of height and tooth eruption with the pre-puberty, during puberty and post-puberty periods, as tooth eruption continues even after teeth have reached occlusion (Björk and Skieller, 1983). Tooth eruption and growth of the alveolar process are mutually correlated events (Björk, 1955; Björk, Jensen and Palling, 1956), and growth in height is strongly correlated with jaw growth (Björk and Skieller, 1983). Growth of the alveolar process and gains in height are both slow during the pre-pubertal period. The growth of the alveolar process, however, increases significantly during puberty, during which time tooth eruption is also accelerated. Tooth eruption decelerates during the post-pubertal period when growth in height and growth of the alveolar process end (Kjær, 2014).

Wedl et al. (2005) reported that the sequence of tooth emergence differs significantly in the lower and upper jaw. Tooth emergence in the lower and upper jaw of male and female probands is symmetrical. There is a tendency for earlier tooth emergence in the lower jaw of both sexes. However, the emergence sequence differs between the lower and upper jaws.

The nine-year cohort study by Poureslami et al. (2015) provided conclusive evidence of the link between the time of emergence of the first-appearing primary tooth and the first-appearing permanent tooth. Delay in the emergence of primary teeth resulted in a delay in the emergence of permanent teeth. Correlations have been demonstrated also between root formation and chronological age and between root formation and skeletal age. The correlation is, however, stronger for root formation and chronological age. Grøn (1962) suggested there was the impact of sexual maturation (pre-pubertal period, during puberty, and post-pubertal period) on the effect of height and weight on tooth movement, tooth formation and bone development.

Disturbances of tooth eruption

Delayed tooth eruption: The causes of delayed tooth eruption are not well known, although the most commonly seen disorder of tooth eruption is that caused by mechanical interference. Mechanical interference may result from the presence of supernumerary teeth, crowding, soft-tissue impaction, and, sometimes, odontogenic tumors and cysts. When there is a disturbance of the tooth eruption, the regular development of the craniofacial complex, which is mostly determined by the physiologic process of eruption, is also disturbed (Suri et al. 2004). Among people with supernumerary teeth, 28-60% usually have associated delay in tooth eruption. Failure of emergence of maxillary incisors is caused mostly by a supernumerary tooth (Patchett et al., 2001; Wise et al., 2002; Jung et al., 2017). Odontomas and other tumors in both the primary and permanent dentitions may lead to delayed tooth eruption. Also, tooth emergence might be obstructed by dense connective tissue or acellular collagen covering the tooth. Such a mucosal barrier could be caused by gingival hyperplasia, which might occur because of hormonal or hereditary causes, vitamin C deficiency, or drugs such as phenytoin (Suri et al., 2004).

Malformations, premature loss of primary teeth, traumatic injuries, malocclusions and some systemic diseases also may modify the rate of tooth eruption (Poreslami et al., 2015). When trauma or pathologies occur at the time when tooth formation is ongoing or when tooth emergence is incomplete, there may be cellular changes in the periodontal ligament. Ankylosis can then occur as fusion of cementum or dentine to the alveolar bone. Damages to the primary teeth can cause delay in the eruption of the permanent teeth. Also, crowding and impactions are believed to be the result of arch-length deficiency, which may be an etiologic factor for them (Suri et al., 2004).

Malnutrition is one of the systemic conditions that can lead to delayed tooth eruption. Agarwal et al. (2003) reported that chronic malnutrition extending beyond early childhood correlates with delayed teeth eruption, and most teeth had a one-to-four-month variation from the mean eruption time. The high metabolic demand of the growing tissues might be negatively influenced by malnutrition during the eruptive process (Almonaitiene et al., 2010). Other systemic disorders associated with delayed tooth eruption are craniofacial dysostosis, hypothyroidism, hypopituitarism, and renal symptoms (de la Tranchade, 2003; Martelli-Júnior, 2011). Ramos et al. (2006) reported that delayed eruption may be related to premature birth and not to a delay in dental development.

Many genetic disorders and syndromes are also associated with delayed tooth eruption. Hereditary gene disorders that affect the cells involved with dental tissue formation may result in disturbances of histogenesis, which may result from disorders of congenital metabolism, infections, nutritional deficiencies, and endocrinopathies (Wise et al., 2002). Genetics influence the timing of tooth emergence, with heritability accounting for as much as 96% of the variation (Wise et al., 2002). Responsible genetic mutations have been found for nearly half of the 25 known human syndromic conditions that play a role in tooth eruption disturbances (Sandgren, 1995). Gapo syndrome is associated with delayed tooth eruption (Sandgren, 1995), but the cause of delayed eruption in people with this syndrome is unknown.

Many other factors may cause delay in tooth eruption. These include inadequate expression of various cytokines (epidermal growth factor, transforming growth factor, interleukin-1, and colony stimulating factor-1), lack of an appropriate inflammatory response, and increased bone density that impedes resorption (Suri et al., 2004; Poureslami et al., 2015). Dental anomalies, such as amelogenesis imperfecta (Collins et al., 1999; Aren et al., 2003), dentinogenesis imperfecta, regional odontodysplasia, and dentine dysplasia may also be associated with delayed tooth eruption (Suri 2004).

Retention of the primary teeth: This often occurs as isolated findings in single teeth. The primary molars are most often affected. Retention may result from associated space problems or failure of the dental follicle to initiate resorption of the overlying bone (Beckto et al., 20002; Kjær, 2010). Secondary retention occurs after the molar has emerged. The cause is largely unknown although Raghoebar et al. (1989) identified interradicular ankylosis as a cause of 81% of the cases. This form of ankylosis can rarely be identified radiographically. Several genetic and medical syndromes such as hyper IgE syndrome, also cause ankyloses and retention of the primary canines and the primary molars (Esposito et al., 2012). Secondary ankylosis is of special importance as it may result in the difficulty of the periodontal membrane to adapt naturally during eruption, resulting in the arrest of eruption. İt also leads to retardation in the growth of the alveolar process compared with that of the neighboring teeth (Kjaer, 2014).

Ectopic tooth eruption: The causes of ectopic tooth eruption are multiple. They may be genetic predispositions (Marks and Schroeder, 1996) or may result from space anomalies, which may be hereditary such as small jaws (Larsen et al., 2010), or acquired such as from early tooth extraction or retained primary teeth. Artmann et al. (2010) suggested there is a correlation between ectopia and morphological ectodermal deviations.

The most common tooth to erupt ectopically is the maxillary permanent canine. The palatal displacement of canines is genetically linked (Peck, Peck and Kaya, 1994) and largely found in dentitions that are late in developing (Becker and Chaushu, 2000). Palatally displaced canines are more prevalent in females (Sacerdoti and Baccetti, 2004) and are associated with malformed teeth (Becker and Chaushu, 2000; Chaushu, Sharabi and Becker, 2002), a reduced vertical relationship, and tooth agenesis (Sacerdoti and Baccetti, 2004). Also, most palatally erupting canines are associated with insufficient space in the dental arch (Jacoby, 1983; Artmann et al., 2010) and deviation of the cranio-skeleton (Caspersen, Christensen and Kjær, 2009; Larsen et al., 2010). The profile of a bucally erupted canine differs from that of a palatally erupted canine, suggesting a different pathway for both types of displacement (Kjaer, 2014).

The ectopic eruption of other teeth, such as the mandibular canine and third molars has also been reported. Transposition, a form of ectopic eruption, is rarely seen in primary dentition, although it is well reported in the permanent dentition (Kjaer, 2014). Transposition is associated with craniofacial alterations of the maxilla (Perk, Perk and Keya, 1994).

Natal and neonatal teeth: These are prematurely erupting teeth (Fauconnier and Gerardy, 1953) arising from a superficial positioning of the tooth germ (Boyd and Miles, 1951), although other etiological factors, such as infection, malnutrition, hypovitaminosis, febrile illnesses, hormonal stimulation and heredity, have been suggested (Cunha et al., 2001). Associated syndromes that have been implicated are Hallerman-Streiff, Ellis-Van Creveld, craniofacial dysostosis, multiple steacystoma, congenital pachyonychia, and Sotos Syndrome (Cunha et al., 2001). Cohen (1984) reported a prevalence of one in every 2000 births, with a predilection for females (Cunha et al., 2001).

Developmental Dental Hard-tissue Anomalies

Developmental defects of the enamel

The laying down of enamel is a gene-determinant activity that occurs in the presecretory, secretory and maturation stages. The presecretory stage is when ameloblasts acquire all the apparatus to enable them to secrete the enamel matrix; the secretory phase is when ameloblasts secrete the entire thickness of the enamel; and the maturation stage is when the ameloblasts allow inorganic ions to be secreted and exchanged for the water and organic contents, resulting in an increase in the inorganic content and the length and width of the enamel prisms.

Amelogenin (*AMEL*), enamelin (*ENAM*), ameloblastin (*AMBN*), enamelicin (*MMP20*), kallikrein (*KLK4*) and tuftelin (*TUFT1*) are the genes responsible for the synthesis of the enamel matrix proteins (Bartlett 2013). Mutations of those genes that play a role in laying down the enamel matrix result in enamel defects. Damage to secretory ameloblasts may also result in enamel defects. When damage occurs during the maturation stage, there is a failure of degradation of some amino acid fractions, leading to organic contaminants residing between the apatite crystals. This contamination can result in the retardation or arrest of further growth of the crystals, which present as bands or patches of chalky, opaque porous enamel (Wong, 2014). Salanitri and Seow (2013) reported that 10% to 49% of healthy children in advanced countries had defects of the emanel in primary dentition and 9% to 63% in permanent teeth.

Demarcated opacities: One form of developmental defect of enamel is that of demarcated enamel opacity. This defect results from trauma to the ameloblasts in either the early or late enamel maturation phase, or results from infection in the secretory or early maturation phases. Trauma can result from an intrusion or lateral luxation of the primary tooth impining on the succedenous tooth. Also, the product of a necrotic primary tooth pulp could be toxic to ameloblasts (Lo, Zheng and King, 2003). Trauma could result from surgery, such as extraction of the primary tooth (Williamson, 1966) or cleft palate repairs (Dixon, 1968).

Suckling, Nelson and Patel (1989) suggest that the cause of the opacity can be determined by the color. Yellow-demarcated opacities result from an insult causing the death of the ameloblasts early in their maturation stage, whereas white-demarcated opacities result from disturbances in secretion in the early and late maturation phases. The insult that causes the demarcated opacity is also less severe but longer lasting than that responsible for causing hypoplasia. Jälevik and Norén (2000) were unable to substantiate this assertion and suggested that the lesion results from two or more interacting non-specific factors. Suga (1989) on the other hand, felt the defect resulted from disturbances in the degradation of the enamel matrix, which is required for enamel maturation.

Fluorosis: This is a diffuse opacity associated with alterations in the translucency of enamel. It results from a continuous low-grade insult due to the exposure of a daily low dose of fluoride over a period during the secretory phase of amelogenesis. There is also the arrest of enamel maturation characterized by a delayed breakdown of amelogenins, which may become entrapped in the defective enamel (Wong, 2014). The diffuse opacities are subsurface hypo-mineralized defects covered by a well-mineralized outer enamel surface. The lesion appears white. If the insult is confined to the secretory phase of amelogenesis, normal maturation occurs, resulting in translucent enamel even if the matrix is abnormal (Wong, 2014). The pathophysiology of fluorosis is unclear. Suggested mechanisms include the toxic effect of flouride on ameloblasts (Denbesten, Crenshaw and Wilson, 1985); the tight binding of proteins to fluorohydroxyapatite crystal, making proteinolysis difficult (Tanabe et al., 1988); and fluoride inhibition of enamel proteinases (DenBesten and Heffernan, 1989). Dental defects resulting from malnutrition diabetes insipidus and residence at high altitude may mimic fluorosis (Wong, 2014).

Enamel hypoplasia: This is a defect of enamel associated with a reduced thickness of enamel due to the reduced quantity of enamel matrix laid down. It is characterized by pitting of the enamel due to the cessation of ameloblastic activity. The duration of the disturbance is reflected in the width of the band of the defect (Wong, 2014). An insult of ameloblasts occurs during the secretory phase of amelogenesis. The severity of the insult determines the extent of the defect and the translucency of the partially formed enamel (Wong, 2014). High daily doses of fluoride may cause hypoplasia (Suckling and Purdell-Lewis, 1982; Suckling and Thurley, 1984). Other causes are irradiation of the head and neck (Pajari, Lanning and Larmas, 1988), poor respiratory response in the postnatal period (Via and Churchill, 1959), malnutrition, infectious diseases during early childhood, gastrointestinal disturbances, cyanotic congenital heart disease, neurological disorders, renal disorders (Wong, 2014), allergies, and lead poisoning (Hartsfield and Cameron, 2016). Suckling, Herbison and Brown (1987) were only able to show a relationship between hypoplasia and chicken pox and could not implicate many of the conditions listed here as risk factors for enamel hypoplasia. Wilson and Cleaton-Jones (1978) also found no association between hypoplasia and exothermal fevers, whereas Jackson (1961) considered exanthematous fevers a cause of hypoplasia of the permanent first molars and a risk factor for hypoplasia of other teeth. Urinary tract infections, convulsions and pneumonia have also been associated with hypoplasia (Suckling and Pearce, 1984).

Amelogenesis imperfecta: This is a hereditary defect of enamel, with an estimated prevalence of 1:800 (Bäckman and Holmgren, 1988) to 1:14,000 (Witkop, 1957). The global prevalence is estimated at less than 0.5% (Gadhia et al., 2012). Amelogenesis imperfecta results from the mutation of five genes: *AMEL* (amelogenin), *ENAM* (enamelin), *MMP20* (matrix metalloproteinaise-20), *KLK4* (kallikrein-4) and *FAM83H* (Gadhia et al., 2012). It appears as varying degrees of hypoplasia, hypomineralization or a combination of the two (Winter and Brook, 1975), affecting both the primary and permament dentition. It results from a gene defect inherited as an X-linked, autosomal dominant or autosomal recessive trait (Wright et al., 2003; Kim et al., 2004). Amelogenesis imperfecta is part of a hereditarily determined syndrome complex that affects the structure and appearance of dental enamel in association with intra-oral and/or extra-oral pathologies, such as tooth sensitivity and fragility (Gadhia et al., 2012), and it is less common than acquired enamel defects (Wong, 2014). Associated features include delay in dental eruption, microdontia, deviant crown and morphology, root resorption, short roots, enlarged pulp chamber, pulp stones, dens in dente, tooth agenesis, crowding of teeth, gingival enlargement, gingivitis and periodontitis (Gadhia et al., 2012).

Molar incisor hypomineralization: This is a developmental defect of enamel, which may result from environmental insults such as dioxins and high concentrations of chemical compounds in the atmosphere. Other possible toxins include hypervitaminosis D, chronic lead poisoning, diphosphonate, and polychlorinated biphenyl poisoning (Wong, 2014). Children at increased risk for the lesion are those with low birth weight (Seow, 1996), frequent medical problems at the time of delivery, and respiratory diseases resulting in oxygen deprivation (van Amerongen and Kreulen, 1996). Beentjes, Weerheijm and Groen (2002) could not establish an association between molar incisor hypomineralization and pregnancy-related and birth-related complications. There is also no clarity about whether it is caused by childhood diseases, therapeutics commonly used for the management of these diseases, or environmental toxins (Hubbard et al., 2017). The suggestion has been made, however, that there is a genetic predisposition to the lesion, with one or more systemic insults leading to its expression (Krishnan and Ramesh, 2018). The sporadic occurrence of distinctively well-delineated hypomineralized enamel lesions (termed "demarcated opacities") on one to all four permanent first molars precludes a simple causal association with systemic disturbances (Hubbard, 2018).

More recently, Mangum et al. (2010) found a correlation between molar incisor hypomineralization and albumin present in blood, tissue fluid, and saliva. It is speculated that albumin inhibits enamel mineralization. Although Farah et al. (2010) demonstrated albumin in both normal enamel and demarcated opacities, the albumin may also have resulted from post-eruptive contamination with blood or saliva (Hubbard et al., 2017). Also, there are suggestions that molar incisor hypomineralization is a phenotype of amelogenesis imperfecta because of the absence of amelogenin in the chalky opacities, thus making it look like a hypocalcification defect (Hubbard et al., 2017).

Molar incisor hypomineralization is a result of an insult to the ameloblasts during the maturation phase of enamel formation (Jasulaityte, Veerkamp and Weerheijm, 2007), causing changes in the organic and inorganic composition of the affected teeth (Alaluusua, 2010). The defect does not result in a reduction in the thickness of enamel but appears as a discoloration of the enamel (white, cream, yellow, or brown), sharply demarcated from normal enamel. However, the post-eruption disintegration of enamel is possible due to masticatory stress. The teeth affected are one or more permanent first molars with or without an effect on the incisors, although effects on the primary second molars have been reported (Elfrink et al., 2014; Temilola, Folayan and Oyedele, 2015). Hypomineralization usually affects the cusp tip and follows the incremental lines to the cemento-enamel junction (Farah et al., 2010).

A pooled global prevalence of 14.2% has been reported (Dave and Taylor, 2018), with prevalences ranging from 2.4% to 40.2% (Jälevik, 2010). The pooled prevalence is highest in South America (18%) and lowest in Africa (10.9%), with the prevalence in countries in Europe ranging from 3.6% to 25% (Weerheijm and Mejàre, 2003). There is no difference in the prevalence between male and females, and the prevalence is higher amongst children aged ten years or younger than amongst older children (Dave and Taylor, 2018).

Developmental defects of dentine

Dentinogenesis imperfecta: It is the most common type of developmental defect of dentine (Seow, 2014). It is a hereditary disorder caused by various mutations in the dentine sialophosphoprotein gene (Koruyucu et al., 2018, Seymen et al., 2015; Yang et al., 2015), which is inherited in an autosomal dominant fashion, with an associated abnormal dentine structure affecting the primary and/or secondary dentitions (Barron et al., 2008). The loss of scalloping of the dentino-enamel junction allows for easy and early enamel loss and exposure and wear of the dentine. The tooth usually appears opalescent. Three types of anomalies are associated with dentinogenesis imperfecta.

The Shield Type I anomaly is an autosomal dominant lesion resulting from missense mutations of the genes *COL1A1* and *COL1A2* that encode type I collagen (Barron et al., 2008). The clinical features are varied and complex (Seow, 2014). Shield Type II and III anomalies do not have associated bone defects. Type II and III defects are associated with mutations of the dentine sialophosphoprotein gene. The absence of associated bone defects may be due to the low expression level of the gene in bone, molecular redundancy involving other extracellular matrix proteins found in bone, or altered proteolytic processing. It is also possible that associated bone defects go undetected because they are very mild in nature (Barron et al., 2008). Type II lesions are associated with teeth that have bulbous crowns, marked cervical constriction, short roots, or obliterated pulp chambers and root canals. Type III, known as the Brandywine type, is found in the triracial Brandywine population of Maryland (Shapir and Shapira, 2001); the teeth in the primary and permanent dentition have large pulp chambers (Shapir and Shapira, 2001).

Dentine dysplasia: This is a rare genetic disturbance of the radicular (type 1) or coronal (type II) dentine formation associated with the loss of organization of dentine during tooth formation (Kwon and Jiang, 2018). Type 1 is inherited in an autosomal-dominant fashion and affects both the primary and permanent dentitions. The mutation causing the defect is within the *DSPP* gene (Bloch-Zupan, Sedano and Sculy, 2012). The roots are short and may appear more pointed than normal. The pulp is often completely obliterated in the primary dentition and reduced in space in the permanent dentition (Bloch-Zupan, Sedano and Sculy, 2012). In most cases, the morphology of the crown is normal, but there are few cases in which the crown is small with an aberrant shape. Lesions associated with aberrant crowns are present in those with a splice-site mutation in the *SMOC2* gene (Hartsfield and Cameron, 2016). Dentine dysplasia is associated with premature tooth exfoliation, root fracture (Kwon and Jiang, 2018) and delayed tooth eruption (Bloch-Zupan, Sedano and Sculy, 2012).

Type II dentine dysplasia is also inherited in an autosomal-dominant fashion, with features of the crowns of the primary teeth being like those of dentinogenesis imperfecta Shield Type II. The crown of the prinar tooth is bulbous with cervical constriction, thin roots, and early obliteration of the pulp (Kwon and Jiang, 2018). The permanent teeth appear normal, but the pulp configuration is like a thistle tube, with the pulp chamber enlarged with an apically extended pulp chamber (Kwon and Jiang, 2018) and pulp obliterated with pulp stones (Hartsfield and Cameron, 2016). Type II dentine dysplasia results from a dentine sialophosphoprotein gene missense mutation, which causes the disruption of signal-peptide processing and/or related biochemical events that interfere with dentine formation protein processing. This sequence is like that in dentinogenesis imperfecta Shield Type II, a similarity that suggests that dentine dysplasia type II is a milder form of dentinogenesis imperfecta Shield Type II (Hartsfield and Cameron, 2016).

Developmental defects of cementum

Hertwig's epithelial root sheath is derived from the cervical loop of the enamel organ. The sheath determines root number, shape, and length. Mesenchymal fibroblast growth factor 10 and epithelial growth factor receptors are associated with Hertwig's epithelial root sheath development. Hertwig's epithelial root sheath cells are active in cementogenesis (Luder 2015).

Hypophosphatasia: This is a systemic disorder associated with anomalies of root development (Reibel et al. 2009, Luder 2015). Anomalies associated with cemental formation defects may disrupt the dentition through premature loss of primary and permanent teeth. Hypophosphatasia is characterized by reduction of total serum alkaline phosphatatase activity, excretion of phosphoethanolamine, and defective bone and tooth mineralization. There is aplasia and hypoplasia of the cementum and abnormal interglobular dentine in the predentine area (Reibel et al. 2009).

Regional odontodysplasia: This is a rare inherited disorder affecting enamel, dentine, root, pulp, and follicle of primary and permanent dentitions. Usually, the teeth on one quadrant of the dentition are affected. The prevalence is unknown. İt is assumed to result from local circulatory disorders, viral infections, teratogenic drugs, neural crest cell defects, vascular defects, irradiation, rhesus incompatibility, local trauma, local somatic mutation, hypophosphatasia, hypocalcemia, hyperpyrexia, nutritional deficiency, circulatory disorders, and idiopathic factors (Koruyucu et al. 2018).

Anomalies of tooth number, size, and shape

Usually, these anomalies are asymptomatic but of significance as they may lead to problems such as delayed eruption, poor esthetic occlusal interference, accidental cusp fracture, interference with the tongue space causing difficulty in speech and mastication, temporomandibular joint pain and dysfunction, malocclusion, periodontal problems, and increased susceptibility to caries (Shresth et al., 2015). Local and systemic disturbances, including genetic disorders associated with any of the over 300 genes responsible for odontogenesis (Thesleff, Keranen and Jernvall, 2001), occurring before or after birth, may be responsible for these anomalies. Recently, the role of heredity in the cause of these anomalies has been examined.

Supernumerary: This refers to an additional tooth that can be seen in either the primary or permanent dentition. The most widely accepted theory about its cause is the hyperactivity theory, which proposes that supernumeraries result from local, independent hyperactivity of the dental lamina. The prevalence of this developmental anomaly ranges from 0.1% to more than 3% (Aly Ahmen et al., 2018). Supernumerary teeth may be associated with tooth agenesis. Also, enamel defects, such as molar incisor hypomineralization tend to be associated with developmental dental hard-tissue anomalies, such as agenesis of second premolars or co-occurrence of tooth agenesis and supernumerary teeth (Koruyucu et al., 2018).

Hypodontia (tooth agenesis): This common dental anomaly is the congenital absence of at least one tooth. Its cause is thought to be multifactorial, with many genetic and environmental factors contributing to its expression. It is also associated with many syndromes, cleft lip and palate, congenital deformities, and some systemic diseases. Mutations in *MSX1*, *PAX9*, *EDA1*, *WNT10A* and *EDARDD* genes are responsible for isolated hypodontia (Bilgin and Kaya, 2018). In addition to *MSX1* and *PAX9*, the genes *TGFA*, *IRF6*, *FGFR1*, *AXIN2*, *MMP1*, and *MMP20* have been associated with hypodontia, an association suggesting that the lesion fits a polygenic mode of inheritance rather than a single-gene disorder (Küchler et al., 2001; Vieira et al., 2004; 2007; 2008; Callahan et al., 2009). Hypodontia in the primary dentition is less common than in the permanent dentition, with a prevalence of 0.5% to 2.4%. In the permanent dentition, the prevalence ranges from 4% to 6% of the population (Larmour et al., 2005). It is frequently non-syndromic, but may be associated with a syndrome. Abnormalities commonly associated with hypodontia are ectodermal dysplasia, cleft lip and palate, Van der Woude Syndrome, Down syndrome, and others (Lamour et al., 2015).

Concrescence: Concrescence is a rare twinning dental anomaly of the union of juxtaposed teeth in the cementum only – not in the dentine (Gunduz et al., 2006; Mehdizadeh et al., 2016). It is most frequently present in the posterior maxilla, especially the third molar and supernumerary teeth. It is rarely present in the mandible (Foran et al., 2012). Concrescence may be present in either the primary or permanent teeth. Its reported incidence is 0.8% for permanent teeth and 0.2% to 3.7% for primary teeth (Syed et al., 2016). The cause of concrescence is not known, but implicated factors are space restriction during the development of dental follicles, local trauma, excessive occlusal force, or local infection after development (Mehdizadeh et al., 2016). Concrescence may cause complications during dental treatment, including periodontal destruction, alveolar bone fracture, tooth fracture, and sinus opening during extraction (Syed et al., 2016).

Fusion: Fusion (synodontia or false gemination) is defined as the union of two or more separate developing tooth germs at the dentinal level, yielding a single large tooth during odontogenesis when the crown is not yet mineralized. The possible causes of this tooth anomaly include trauma and environmental factors such as thalidomide embryopathy, fetal alcohol exposure, and hypervitaminosis. These anomalies are more common in the anterior region. Approximately 0.1% occur in permanent and 0.5% in primary dentition (Tuna et al., 2009).

Gemination: Geminated teeth (twinning) are similar to fused teeth. They have two crowns or one large partially separated crown with a shared single root and root canal. In geminated teeth, division is usually incomplete and results in a large tooth crown that has a single root and a single root canal. It is difficult to differentiate fusion and gemination, especially if the supernumerary tooth bud is fused with the adjacent one. Although the cause of these anomalies is unknown, it is believed that some physical force or pressure/trauma causes contact between developing teeth, thus producing necrosis of the epithelial tissue that separates them and leads to fusion or gemination (Tuna et al., 2009). Both types of tooth-shape anomalies may result in esthetic problems and, thus, may require endodontic, restorative, surgical, or orthodontic treatment. They can also cause psychological problems, especially in children.

Dens evaginatus: Dens evaginatus is a developmental deviation of a tooth that results in an accessory cusp formation described as an abnormal tubercle, elevation, swelling, extrusion or protrusion in various ways (Levitan and Himel 2006). The projection has enamel covering a dentinal core that contains pulp tissue, possibly a thin pulp horn that can extend various distances up to the length of the tubercle's dentin core (Neville et al., 2002). It most often arises from the occlusal surface of a posterior tooth and primarily from the lingual surface of the associated anterior teeth. Although dens evaginatus was first reported in 1892 and has been documented since 1925, its cause remains uncertain (Leigh, 1925; Kocsis et al., 2002). It is present predominantly in people of Asian descent (Chinese, Malay, Thai, Japanese, Filipino, and Indian populations), with a prevalence of 0.5% to 4.3% in the various populations (Kocsis et al., 2002; Levitan and Himel, 2006). A higher incidence (15%) has been reported in Alaskan Natives and North American Indians (Yip, 1974). These patterns suggest the lesion may be inherited. The association of dens evaginatus with other developmental anomalies, such as shovel-shaped incisors that also occur frequently in Asian populations makes the possibility of inheritance likely (Yip 1974; Levitan and Himel, 2006).

Dens invaginatus: Dens invaginatus is a rare malformation of the teeth, with a wide range of morphological variations. The affected teeth have an enamel and dentine swelling extending into the crown and/or root and sometimes even reaching the root apex, as can be seen radiographically. In addition, the dental crowns may vary in size and form. This anomaly was first described by Ploquet in 1794 in the teeth of a whale (Hülsmann, 1997; Mupparapu et al., 2004). The cause of dens invaginatus malformation is controversial (Hülsmann, 1997). Rushton (1937) suggested that the cause is embryological, with stimulation of the cells of the enamel organ during development and subsequent proliferation and cell growth. Its reported prevalence in the permanent dentition is 0.3% to 10%, and it has been reported in 0.25% to 26.1% of individuals examined (Alani and Bishop, 2008).

Peg-shaped teeth: This is an undersized, tapered tooth that may be associated with other dental anomalies. The incisal mesiodistal width of the crown is less than the cervical width (Kim et al., 2017; Mittal and Mohandas, 2018). It is linked genetically with tooth agenesis (Izgi and Ayna, 2005; Karatas et al., 2014; Mittal and Mohandas, 2018). Its prevalence is 0.6% to 9.9% in various populations (Devasya and Sarpangal, 2016; Kim et al., 2017; Mittal and Mohandas, 2018).

Tuberculum paramolare: Tuberculum paramolare is defined as an additional tuberculum, localized on the mesio-vestibulo coronal surface of the molar teeth. It is present mostly in the upper second and third molars. Due to its growth potential, it might develop a specific root. The cause is unknown, although it is assumed to be genetic in origin (Kucukerler, 1978).

Taurodontism: Taurodontism is an anatomical developmental anomaly with vertically extended pulp chambers and apical displacement of the root furcation area (Ashwin and Arathi, 2006; Manjunatha and Kovvuru, 2010). Suggested causal factors are the failure of Hertwing's epithelial root sheath to complete root formation and interference in the epithelia-mesenchymatose induction, as well as genetic inheritance (Benazzi et al., 2015). Its overall prevalence has been reported by some (Luder, 2015; Aren et al., 2018) to be 0.25% to 11.3%, but Kırzıoğlu et al. (2018) reported a higher prevalence of 23.8%.

Dilaceration: This is an anomaly in which there is a sharp bend of either the crown or root axis (Andreasen, Sundström and Ravn, 1971). Its reported prevalence is 0.42% to 98%. This wide range of prevalence may be due to differences in its definition, including a mix-up with a smooth physiologic or abnormal curvature of the root (Luder, 2015). Posterior teeth are more frequently affected. Dilaceration of the anterior teeth is often associated with trauma to the primary predecessors at the age of 2-3 years when the crown of the developing permanent tooth lies lingual to the root of the primary predecessor. Its cause in the permanent teeth is not clear. Intrusive trauma to the primary tooth may cause dislocation of the crown to the lingual side, leading to crown dilaceration. When intrusive trauma occurs at about the age of 4-5 years at a time when crown formation of the permanent successor is largely complete, root dilaceration occurs (Luder, 2015).

Enamel pearls: The enamel is normally limited to the anatomical crowns of the human permanent teeth. If the enamel is present ectopically on the root, especially in the furcation area and close to the semento-enamel junction, it is named enamel pearls or cervical enamel projections (Colak et al., 2014; Mariz et al., 2018). It can be classified into three groups based on its structure: simple, composite, and composite with a pulp chamber. A simple enamel pearl is composed of only enamel; a composite enamel pearl is composed of dentine and enamel; and a composite enamel pearl with a pulp chamber consists of enamel, dentine, and the pulp chamber. The pulp chamber can be an extension of the coronary or root pulp (Rocha et al., 2018). Its cause is unknown. The most plausible hypothesis is that it develops from residues that remain attached to the root surface during the localized formative activity of Hertwig's epithelial root sheath (Colak et al., 2014; Al-Zoubi et al., 2018). Its prevalence is 0.83% to 9.7%. Enamel pearls are rarely found on single-rooted teeth and are more common in molars, especially in second and third maxillary molars, where they are most commonly located in the bifurcation area between the distobuccal and palatal roots (Rocha et al., 2018).

Microdontia: Microdontia is a tooth smaller than the normal size for that tooth in a given population. Localized microdontia is the most common expression. Generalized microdontia is associated with congenital diseases such as hypopituitarism, ectodermal dysplasia or Down syndrome. Radiation therapy to the jaws during tooth development is also an ethiologic factor. The most frequently affected teeth are the maxillary lateral incisor and third molars (Rohilla, 2017).

Macrodontia: Macrodontia is defined as teeth that are larger than normal. It is detected more often in the primary teeth than in the permanent teeth and can be classified into general and local macrodontia. In general macrodontia all the teeth are larger than normal, and there are associated syndromes such as gigantism. Local macrodontia involves a single tooth, which is difficult to keep within the dentition. Double formations, such as fusion or gemination, are not macrodontia (Rohilla, 2017).

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DENTAL DEVELOPMENT: ANTHROPOLOGICAL PERSPECTIVES

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Introduction

Dental or tooth development encompasses the processes of tooth mineralization, calcification, eruption and maturation (Garn et al., 1958; Smith, Crummett and Brandt, 1994; Liversidge, 2003). This set of processes is also erroneously referred to as *tooth formation,* which is specifically the formation of an organic matrix and its subsequent mineralization and calcification (Smith, Crummett and Brandt, 1994). *Eruption* is the process of tooth movement that takes the tooth through the bone, piercing the alveolus and oral mucosa until it reaches an opposing tooth (El-Nofely and İşcan, 1989). Mani, Naing and Samsudin (2008) argued that the term eruption is vague since it is a continuous process including the period in life when no tooth erupts into the oral cavity. The ill-defined concept of tooth eruption makes comparisons between studies difficult. As a result, Demirjian (1986) posited that the term *tooth emergence* should be used to refer to the period when any part of the crown appears in the oral cavity during eruption.

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Documentation of the timing of tooth formation and emergence is important as they are indices of dental development and the chronological age of children and young adults in a population (Haavikko, 1974; Demirjian and Goldstein, 1976; Teivens and Mörnstad, 2001; Lewis and Rutty, 2003; Cattaneo, 2009). These indices are important also for assessing growth changes (Scheuer and Black, 2000), comparing growth trajectories or patterns of growth among populations or species (Liversidge, 2003), and estimating the age for archeological and forensic purposes (Scheuer and Black, 2007). They provide data on biological growth and development that are useful for assessing the health status. In the absence of population-specific data on the timing of tooth formation and emergence, researchers compare growth in the population of interest to standards for children in Europe or the United States. Such comparisons across populations can result in misrepresentations of the health status of the population of interest.

Population-specific growth standards are important and useful not only in biological anthropology and health research, but also for determining the identity of persons who have no birth records (Kim, Kho and Lee, 2000; Yun et al., 2007). Data on the timing of tooth formation, emergence and morphometrics are significant also for forensic purposes, especially with the increasing global incidences of mass death and disasters (Kieser, Laing and Herbison, 2006; Perrier et al., 2006). Tables of tooth-emergence chronology are valuable when birth records are unreliable or lost, where people are seeking asylum (Schmeling et al., 2007), and for age determination to prevent cheating in age-graded sports competitions (Schulze et al., 2006; Meijerman et al., 2007; Ríos, Weisensee and Rissech, 2008; Baumann et al., 2009; Ríos and Cardoso, 2009). The dental age at death is usually the only reliable biological marker in unidentified remains of juveniles (Scheuer and Black, 2000). Also, information from dental development records may aid in determining treatment options and sequential decision-making (Suri, Gagari and Vastardis, 2004). Dental development is also important for the study of life history – the pattern and tempo of juvenile development; age of sexual maturity and first reproduction; number of offspring; interbirth intervals; level of parental investment; senescence and death (Bogin and Smith, 1996). Dental development may reflect how reproductive development, post-reproductive behavior and life span are shaped by natural selection (Stearns 2000), and knowledge of it helps in exploring biological and behavioral diversity among human populations.

Dental Development and Life History

First molar emergence and life history: Indices of growth and development such as skeletal, dental and sexual maturity have been correlated for many primates species; tooth emergence has a strong relationship with these variables in extant and fossil species (Harvey and Clutton-Brock, 1985; Smith, 1989; Smith, 1991; Smith, 1992; Smith and Tompkins, 1995; Bogin and Smith, 1996; Bogin, 1997; Bogin, 2010; Lee et al., 2011; Thompson and Nelson, 2011; Kelley and Schwartz, 2012).

Relationships between the timing of the first molar emergence and life-history events in primates are well documented (Smith, 1989; Smith, 1994). Age at the emergence of the first molar strongly correlates with age at weaning, age at sexual maturity, and somatic measurements such as the adult brain mass, neonatal body mass and brain mass (Smith 1989). Similarly, the age at emergence of the mandibular first molar correlates highly with the age at emergence of all other tooth types and the duration of tooth eruption (Smith, 1992; Smith, Crummett and Brandt, 1994). The strong relationship between tooth emergence and life-history events in primates makes it possible to use dental development to draw inferences on life-history evolution (Harvey and Clutton-Brock, 1985; Smith, 1991; Smith and Tompkins, 1995; Bogin, 2010; Lee et al., 2011; Thompson and Nelson, 2011; Kelley and Schwartz, 2012). For example, the earlier age of mandibular first molar emergence in human ancestral species (hominins) compared to wild great apes is an indication that the earliest hominins had more rapid life histories (Kelley and Schwartz, 2012). The documentation of delayed timing for the first molar emergence characteristic of modern humans has now been verified for ancient *Homo* in China (Xing et al., 2019).

However, the extended timing of life history events of certain species compared with that of other species, especially in closely related great apes, raises questions about the relationship between weaning and mandibular first molar emergence (Dirks and Bowman, 2007; Robson and Wood, 2008; Guatelli-Steinberg, 2009; Humphrey, 2010). For example, the mandibular first molar emerges before weaning in orangutans, gorillas, and chimpanzees (Robson and Wood, 2008). Humans are typically weaned long before the emergence of the mandibular first molar, whereas chimpanzees continue to breastfeed even after the emergence of this tooth (Robson and Wood, 2008; Smith 2013). Thus, in contrast with great apes, humans are weaned early relative to their permanent dental development

(Humphrey, 2010; Robson and Wood, 2008), indicating no relationship between weaning age and mandibular first molar eruption. This is not unexpected, given that weaning in modern humans is highly variable and culturally determined.

Tooth emergence variation in modern humans: Modern humans have a unique life history. We have relatively short birth intervals; helpless newborns; a high rate of postnatal brain growth; an extended period of offspring dependency; intense levels of maternal and paternal care; a prolonged period of maturation; a marked adolescent growth spurt; and delayed reproduction cycles (De Castro et al., 2003). Study of the Baka population (one of the groups formerly referred to as "African pygmies") in the Republic of Cameroon suggested that relationships between life-history events and tooth emergence are disrupted in humans compared to other primates (Rozzi, 2016). Baka have short stature because of a slow rate of growth early in development, and advanced tooth emergence (Rozzi, 2016). Their tooth emergence occurs earlier than that documented for other African, European and Asian populations (Esan, Mothupi and Schepartz, 2018). Though the timing of life-history events varies among human populations, the pattern is the same.

Dental development and brain development: Brain development is an essential component of life history patterns. Brain metabolism and energy processing set the pace for vertebrate growth and aging (Sacher and Staffeldt, 1974). Dental development is very resistant to environmental perturbations unlike brain growth and development, which can be greatly influenced by environmental factors (Lewis and Garn, 1960). Therefore, brain weight and the timing of tooth formation and emergence are two different components in the life history of primate species although both are influenced by growth hormones. Brain size is, however, highly correlated with dental development in primates (Smith, 1994; Allman and Hasenstaub, 1999; Kelley and Schwartz, 2010). Strong correlations have also been found between age of first mandibular molar emergence, age at completion of tooth emergence, and brain size in hominins (De Castro et al., 2003).

Dental development and sexual maturity: The relationship between sexual maturity and dental development in humans is not clear. Lewis and Garn (1960) found a moderate correlation between the onset of menarche and the occlusal level of the second mandibular molar. Nanda (1960) found a similar correlation between the age of completion of permanent teeth emergence and menarche. Furthermore, the third mandibular molar emergence was strongly correlated with life history and somatic variables, especially age of sexual maturity. Conversely, Björk and Helm (1967) found a low correlation between age at menarche and tooth emergence, and Filipsson and Hall (1975) found a low correlation between dental maturity, measures of sexual development (age at menarche, breast and pubic hair development), and the age of peak height velocity (the period where maximum growth occurs). Hägg and Taranger (1982), in a longitudinal study of Swedish children, found that the stages of dental emergence were not reliable indicators of the pubertal growth spurt. Demirjian et al. (1985) found no significant relationships between dental development and other maturity indicators such as sexual maturity and peak height velocity in French Canadian girls who had attained 90% of their dental development. Therefore, Demirjian et al. (1985) argued that the mechanisms controlling dental development are independent of somatic and sexual maturity. This perspective has contributed to the view that dental development does not vary in the same way as other aspects of development.

Tooth Formation in Humans

Multiple methods are used to study the timing of tooth formation. The most widely used is that developed by Demirjian and his colleagues (Demirjian, Goldstein and Tanner, 1973; Demirjian and Goldstein, 1976). The Demirjian method is based on the study of a large, random sample of French-Canadian children, which assesses changes in tooth formation from the initial calcium deposition to completion of apex formation. This process is divided into eight observable stages. The assessment is applied to seven permanent teeth of the left mandibular teeth (exclusive of the third molar), and the individual "scores" for each tooth are summed. The resulting sum is referenced on a corresponding conversion chart, with dental ages ranging from 3 to 17 years in increments of one-tenth of a year.

Although the dental age predicted by the Demirjian method was found to be a good estimate of the chronological ages of the original French-Canadian sample and the stages have been proven to be universally applicable, the conversion to dental ages in different populations has been questioned (Willems et al., 2001; Chen et al., 2010; Baghdadi and Pani, 2012; Erdem et al., 2013). For example, Tunc and Koyuturk (2008) showed that the method was less accurate in predicting the chronological age of Turkish children, who had more advanced dental maturity than that of age-matched French-Canadian children. The method also overestimated the chronological age of Belgian children (Willems et al., 2001) and Black South African children (Esan and Schepartz, 2018a). However, after an extensive review, Liversidge (2012) concluded that the Demirjian method is a well-suited forensic tool for determining chronological age in sub-adults.

The general pattern of variability in the overestimation of ages documented by published studies suggests that the timing of dental development may be influenced by genetic and environmental factors. Tables of tooth formation and age of attainment of specific developmental stages from one region of the world may not apply in a different setting. The documentation of significant variation in dental maturation among human populations, which is growing with expanded research that includes a broader range of populations, needs to be recognized and accounted for in the same way that skeletal and other aspects of growth variation are considered. When the highest levels of accuracy in age estimation are required, population-specific standards to need be developed, rather than working toward a global standard.

Tooth Emergence in Humans

Dental development is commonly assessed by means of tooth emergence which is far easier and more economical than radiographic or other methods (Helm and Seidler, 1974; Holman and Jones, 1991; Al-Jasser and Bello, 2003). The mean age at which teeth emerge has been derived using various analyses of data collected from cross-sectional studies (Hayes and Mantel, 1958). Some methods used graphic illustrations and percentiles, but this method adjusted the mean age for possible confounders. Healy (1986) posited that computing the mean age of attainment of a distinct developmental process should be based on a cumulative frequency curve; this computation allows for an adequate age range that is cognisant of children who are early, average, and late developers (Smith, 1991). Statistical methods suitable for determining the mean age and range at which 50% of children are likely to have a tooth emerge include probit analysis, Kärber’s method, life tables, and maximum likelihood analyses. These are suitable measures that correspond to the median age (Liversidge, 2003).

The timing of tooth emergence is, however, not synonymous with the age of tooth eruption (Mani, Naing and Samsudin, 2008), and it is affected by multiple factors such as odontogenic infections, tooth impaction, premature extraction of the primary teeth, and crowding of the permanent dentition (Holt, Chidiac and Rule, 1991). The impact of these factors on the timing of tooth emergence results in differences in the timing of tooth development among children of the same chronological age. To address this difference, the concept of *physiologic age* – the period between completion of tooth development and tooth maturity – was introduced (Moorrees, Fanning and Hunt, 1963). Thus, physiologic age, which is also known as biological or developmental age, defines the age status of the child. *Chronological or calendric age,* on the other hand, is a rough estimate of what the physiological age should be, independent of the confounders of development, for a specific age.

Dental Maturity Charts

Dental maturity charts depicting tooth-specific crown and root formation stages are employed for age estimation. The benefits of using charts or atlases over other formats are the ease and speed with which they can be applied to diverse anthropological, forensic and bioarcheological investigations. Until the call for greater accuracy in forensic casework (Dirkmaat et al., 2008), the global use of dental development charts was not extensively evaluated. Many charts (Schour and Massler, 1941; Gustafson and Koch, 1974; Brown, 1985; Kahl and Schwarze, 1988; Blenkins and Taylor, 2012; AlQahtani, Hector and Liversidge, 2014) are based on data from clinical populations of European ancestry, although some were developed on archeological samples (Ubelaker, 1978). The most recent development for global use, the London Atlas, incorporates data on British and South Asian children resident in the UK. None of the reference charts take into consideration the advanced tooth emergence and formation patterns observed in African children (Oziegbe, Esan and Oyedele, 2014; Cavrić et al., 2016: Esan and Schepartz, 2018b). A new dental atlas, the WITS Atlas was developed for age estimation in forensic, anthropological, bioarcheological and clinical applications in Southern Africa (Esan and Schepartz, 2018b). The number and magnitude of differences in the timing and stages of permanent tooth emergence and formation between the WITS and the London Atlases illustrate that a global atlas is not suitable for a situation where the level of accuracy needs to be within 6 months or at most one year (McKenna et al., 2002; Flood et al., 2011).

Variations in Dental Development in Humans

Four main developmental indicators are used for estimating physiological age (Moorrees et al., 1963): stature, secondary sex characteristics, bone growth and dental development. Of these, dental development is the best predictor of chronological age (Demirjian et al., 1985; Demirjian, 1986). Dental development is less variable than other growth-defining events, such as the appearance of bone ossification centers. There is a stronger association between chronological age and dental age than between skeletal age and dental age (Lewis and Garn, 1960).

Dental development varies by sex and population (Demirjian and Levesque, 1980; Willems et al., 2001; Tunc and Koyuturk, 2008). Therefore, data on tooth formation and emergence need to control for these factors (Oziegbe, Esan and Oyedele, 2014). With globalization, there are demographic changes as well as changes in the physical profiles and dental characteristics of populations. These stem from modifications of nutritional and socio-economic statuses as well as population admixture (Kearney, 1995). New studies are needed to monitor the dynamics of population level dental evolution and to elucidate anthropological questions regarding historical lineages of human groups.

Population variation in dental development: Dental development varies among populations and ethnic groups (Davis and Hagg, 1993; Willems et al., 2001; Chen et al., 2010; Cruz-Landeira et al., 2010; Ogodescu et al., 2011; Baghdadi and Pani, 2012; Erdem et al., 2013). The increasing use of dental development reference values in forensic settings and legal determinations, necessitates the highest degree of accuracy in age estimation. Consequently, several authors have argued for population-specific databases (Willems et al., 2001; Tunc and Koyuturk, 2008; Chaillet and Demirjian, 2004; Chaillet, Nyström and Demirjian, 2005; Baghdadi and Pani, 2012; Lee et al., 2011; Esan, Yengopal and Schepartz, 2017; Esan and Schepartz, 2018a; Esan and Schepartz, 2019).

The reason for the variation among populations is unknown, although genetic and environmental factors may play a role (Chaillet, Nyström and Demirjian, 2005). Environmental factors, such as temperature and humidity, can cause an adaptive response that may accelerate or delay tooth development (Smithers and Smith, 1997). Eveleth (1966) provided evidence that populations living in the tropics are dentally advanced. White American children living in Brazil, who were socio-economically matched with children living in the United States, had earlier permanent tooth emergence.

Sex variation in dental development: It is well established that females are more advanced in their tooth formation in all populations (Demirjian, 1973; Kochlar and Richardson, 1998; Eskeli et al., 1999; Moslemi, 2004; Oziegbe, Esan and Oyedele, 2014; Esan and Schepartz, 2018a; Esan, Mothupi and Schepartz, 2018). In the studies, gender variables were often significant for the maxillary lateral incisors and canines (Kochlar and Richardson, 1998). Earlier emergence of permanent teeth in girls has been ascribed to an earlier commencement of physiological maturation (Almonaitiene, Balciuniene and Tutkuviene, 2010). Males are more affected by environmental stresses than are females, especially during the prenatal period (Tobias, 1972; Wolanski and Kasprzak, 1976; Stinson, 1985). Sex-based differences detected in the timing of specific developmental events are documented across populations and provide evidence for the genetic contribution to many aspects of male-female dental differences.

Socioeconomic variation in dental development: The effect of socioeconomic status on dental development remains controversial due to the complex interplay of health care and nutritional factors. Elamin and Liversidge (2014) reported that malnutrition in severely undernourished children in South Sudan had no significant impact on dental development. Conversely, a recent study of Black Southern African children documented significant differences in the timing of tooth formation in children according to nutritional status (Esan, Mothupi and Schepartz, 2018). The study demonstrated the advanced timing of tooth formation in normal weight and overweight, compared with underweight, Black Southern African children. The effect was mainly noticeable for children in the extremes of the spectrum of the BMI z-scores. Earlier studies among American children (Garn et al., 1973; Clemens, Davies-Thomas and Pickett, 2009) found that children with high socioeconomic status had earlier tooth emergence. Oziegbe, Esan and Oyedele (2014), however, did not find a consistent difference in the time of emergence of the permanent dentition among socioeconomic classes – a possible reflection of nutritional status – in a Nigerian population.

Future Directions and Recommendations

The growing recognition of variation in the tempo of dental development in contrast to earlier perspectives that downplayed population diversity, is leading to a more nuanced understanding of dental development.

The use of dental development has expanded to include a broad range of applications beyond dentistry – most notably seen in the rise of forensic dental anthropology and the demand for population-specific data. The use of better modeling and analytical techniques is helping to document significant differences in dental growth parameters among populations. In terms of study design, there is a critical need for community-based studies that are representative of populations and free of the biases inherent in clinical investigations. Even more critically, our understanding of dental development primarily relies on cross-sectional data. Only longitudinal data can answer the emerging questions regarding variation in dental growth trajectories.

Life-history studies are an aspect of dental anthropology in which more research is needed. While the relationship between dental development and life-history variables has been widely studied in primates, with high correlations found across species, few comparable studies have been conducted on *Homo sapiens.*

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BELARUS

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Background Information on the Republic of Belarus

The Republic of Belarus occupies an area of 207,600 km². Its neighboring countries are Russia, Ukraine, Poland, Lithuania and Latvia (Figure 1). Belarus is a presidential republic, with a president and a National Assembly made up of two chambers. The country's capital is Minsk. Belarus is organized into six regions/districts (Vitiebsk, Mahilou, Homiel, Hrodna, Brest and Minsk). In 2016, the population was 9,498,700, of which 4,416,895 (46.5%) were male and 5,081,805 (54.5%) were female. Seventy-five per cent of the population are urban dwellers, while 25% live in rural areas (http://www.belstat.gov.by/en/, 2017). The birth rate is about 16,000 children per annum.

Belarus has a temperate climate with soft and wet winters and warm and wet summers. The average annual temperature ranges between 5.7°C and 8.2°C, with about 20 to 35 days of sun per year. The duration of sunshine is about 1730-1950 hours per year, with higher amounts in the southeast of the country. The country, therefore, has only about one sunny month per year (Okorokov, 2016). For this reason, vitamin D deficiency is a major health problem (Okorokov, 2016). About 90% of children aged 5 to 18 years have significantly lower-than-normal vitamin D blood levels, with implications for optimal calcium and phosphorus metabolism and for normal bone and teeth formation (Pochkailo, 2014).

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Figure 1 Map of Belarus

On the 26th of April 1986, a catastrophe broke out 12 kilometers off the Belarusian border – the major break-down of the power unit at the Chernobyl nuclear power station, resulting in the explosion of its failed reactor. A huge amount of radioactive substances was released into the atmosphere. The Chernobyl accident is the most severe catastrophe in world history in terms of its scale, complexity and long-term consequences. Physical craters from the explosion were present in 23% of the territory of Belarus, 4.8% of the territory of the Ukraine and 0.5% of the territory of Russia. The impact of the radiation in these areas is expected to persist up to 24,390 years after the explosion due to a very long half-life of some elements.

After the Chernobyl accident, Belarus became an ecological disaster zone. The accident compounded an already grave situation because zones with high chemical pollution had been previously identified. For this reason, 260,000 hectares of agricultural lands were forbidden for farming. Thousands of hectares of forests are contaminated with radioactive elements. Radioactive contamination of ecosystems makes agriculture and forestry challenging, a challenge that will likely persist for several decades (WHO, 2006).

While efforts are being made to reduce the post-accident trauma, the health impact remains grave. People were evacuated from the most dangerous districts, regular medical check-ups and treatment are being provided, and radioactive decontamination and treatment of agricultural soils are being undertaken (Taniguchi, 2006). Health risks persist, though, as children living in contaminated areas have a great risk of thyroid diseases, including cancer. High incidences of calcium-phosphorus metabolism and increases in the prevalence and severity of non-carious pathologies are also observed (Klenovskaya, Drozd and Melnichenko, 2000).

The macro- and micronutrient content of drinking water is high. Almost 21% of water from wells has high nitrate contents, 38% of boreholes have high iron content (https://news.tut.by/society/409345.html), and 90% of drinking water contains fluoride at concentrations below 0.2 mg /l.

Sequence and Timing of Eruption of Primary and Permanent Dentitions

One of the important aspects of assessing children's physical development is the age of teeth eruption. Timely and harmonious teething is an important indicator of biological age. Teething of the primary bite has a great influence on the formation of the child's body and overall development. With the eruption of the primary teeth, vital physiological changes occur, such as eating solid meals, the disappearance of the sucking reflex, and changes in the swallowing pattern (Leontev, Kiselnikova, 2010). Development of active chewing promotes the growth of the jaws and a change in the proportions of the cerebral and facial skull. Speech formation also starts with the eruption of the primary dentition. Teeth formation and eruption are directly connected with speech formation, which is important for social adaptation and mental development (Zueva, 2004). Neonatal and postnatal pathologies that affect the child's development can negatively delay the eruption of the primary teeth, with consequences. One such pathology is rickets (Prokoptceva, 2012). Rickets affects the development of the upper and lower jaws and disrupts primary tooth eruption.

Shakavets (2016) examined 800 children aged 6-36 months to determine the dates of primary teeth eruption. Eruption commenced at the time of tooth perforation of the alveolar gum, with the cutting edge or one hillock exposed. The lower age limit for tooth eruption was determined as the age at which 5% of examined children have erupted the tooth; and the upper age limit was the age when 95% of the examined children had erupted the tooth.

Table 1 shows the date of tooth eruption in children of Belarus. The sequence of eruption of primary teeth was: lower central incisors, upper central incisors; upper lateral incisors; lower lateral incisors; upper first molars; lower first molars; upper canines and lower canines; lower second molars; and upper second molars. Girls had a tendency for an earlier eruption by an average of one month; and the primary upper lateral incisors erupted earlier than the lower lateral incisors. Children who were exclusively breastfed were significantly more likely to have an erupted first primary tooth earlier than those who were non-breastfed (Shakavets, 2016).

Table 1: Timing of primary teeth eruption in Belarus

Jaw	Sex	Teeth				
		central incisors	lateral incisors	canines	first molars	second molars
		Date of primary teeth eruption (months)				
Upper	Boys	7–11	7–13	15–22	11–17	20–27
	Girls	6–10	7–12	14–21	11–16	19–27
Lower	Boys	6–9	8–13	15–22	12–17	19–26
	Girls	6–8	8–13	15–21	12–16	19–26

The time of eruption of the first permanent molars was estimated in 220 children aged 5-7 years (Chernavskaya, 2016). Children were divided into 3 groups: 50 children (24 boys and 26 girls) aged 5 years were in group 1; 50 children (22 boys and 28 girls) aged 6 years were in group 2; and 120 children (63 boys and 57 girls) aged 7 years were in group 3. At the age of 5 years, only 9 (18.0%) children had their first permanent molar. The lower first permanent molar erupted earlier than the upper first permanent molar. Of these, only 2 (4.0%) had all their first permanent molars erupted (Table 2). There were no significant gender differences at the time of eruption of the molars observed.

Table2: Frequency of the eruption of the first permanent molars in 5-7-year-old children

Age, years	N	Upper left molar		Upper right molar		Lower right molar		Lower left molar	
		N	%	N	%	N	%	n	%
5	50	4	8.0 ± 3.8	2	4.0 ± 2.8	6	12.0 ± 4.6	7	14.0 ± 4.9
6	50	40	80.0 ± 5.7	38	76.0 ± 6.0	44	88.0 ± 4.6	43	84.0 ± 5.2
7	120	112	93.3 ± 2.3	111	92.5 ± 2.5	117	97.5 ± 1.6	115	95.8 ± 1.9

In group 2, 43 (86.0%) children had erupted the first permanent molars and 7 (14.0%) children had not erupted any first permanent molars. The lower first permanent molars erupted earlier than the upper first permanent molar. At the age of 7 years, only 3 (2.5%) children had not erupted their first permanent molar. The mean age of eruption of the first permanent molar was 6 years.
The lower permanent central incisors had erupted at 5 years of age in 20 (40.0%) children, at 6 years of age in 38 (76.0%) children, and at 7 years of age in 100% of children.

The upper permanent central incisors had erupted in 7 (14.0%), 22 (44.0%) and 43 (86.0%) children at 5, 6 and 7 years of age, respectively. Though the central permanent incisors erupted earlier in girls, there was no statistically significant difference in the age of eruption between boys and girls.

Yatsuk (2015) studied the pattern of eruption in 488 children aged 12 years. Of these children, 331 (67.8 ± 7.11%) had only permanent dentition, whereas 157 (32.17 ± 2.11%) had mixed dentition. Of those with permanent dentition, 36 (7.38 ± 1.18%) children had no second permanent molar, whereas 295 (64.45 ± 2.21%) had one erupted second permanent molar. Of the children with mixed dentition, 79 (16.19 ± 1.67%) had no second permanent molar, whereas 78 (15.98 ± 1.65%) had one erupted second permanent molar.

Zenkevich (2017) studied the pattern of eruption of the third permanent molars in 360 patients –140 (38.9%) girls and 220 (61.6%) boys, aged 8 to 17 years old with a mean age of 12.5 years –using their orthopantomograms. There were significantly more buds of wisdom teeth in the lower jaw than in the upper jaw; the tooth buds in the upper and lower jaws could be identified in 86.1-97.2% of 8-year-olds. Tooth buds for upper right and left third molars could be identified in 294 (81.7%) and 300 (83.3%) children, respectively. These tooth buds were less often identified in 8-10-year-olds than in 11-14-year-olds. The lower left and right third molars were identified in 333 (92.5%) and 334 (92.8%) children, respectively. The buds of the lower third molars could be identified by 8 years of age, whereas buds of the upper third molars were identified by 10-11 years of age.

Prevalence of Developmental Dental Hard-tissue Anomalies

Yatsuk (2015) examined 504 children (253 boys and 251 girls) aged 8 years and 488 children (246 boys and 242 girls) aged 12 years from Minsk to determine the prevalence of non-caries pathology. No fewer than 50 children of each age group from each of the nine administrative-territorial districts of Minsk were examined.

Of the 504 children examined, 66 (13.10 ± 1.50%) had molar incisor hypomineralization affecting the first permanent molars and incisors, 5 (0.99 ± 0.44%) had hypomineralization of the second primary molars, and 54 (10.71 ± 1.38%) had other hypomineralization defects such as non-molar incisor hypoplasia/hypolastic second primary molar. Turner's tooth was diagnosed in 6 (1.19 ± 0.48%) children, prenatal hypoplasia in 1 (0.20 ± 0.20%) child, and hypoplasia in 1 (0.20 ± 0.20%) child. Unspecified mottled enamel was diagnosed in 77 (15.28 ± 1.60%) children. Some of the children had more than one non-caries pathology.

Molar-incisor hypomineralization was diagnosed in 54 (11.07 ± 1.42%) of the 488 children examined. A hypomineralization defect of second permanent molars was diagnosed in 28 (5.74 ± 1.05%) children. Other hypomineralization defects were diagnosed in 50 (10.25 ± 1.37%) children. Only 3 (0.61 ± 0.35%) children had hypoplasia, but 181 (37.09 ± 2.19%) children had unspecified mottled teeth, and 9 (1.84 ± 0.61%) children had Turner's tooth.

Gaps and Recommendations

There have been many new definitions of lesions, which have led to increasing challenges in identifying the etiology and distinctive clinical features of some non-caries pathology. One of these challenges is the difficulty in making a clinical and etiological distinction between hypoplasia resulting from systemic causes and molar incisor hypomineralization. Available data suggest a decrease in the prevalence of hypoplasia, but there are no explanations for this observation. Perhaps discussions with pediatricians to explore the possible role of vaccination will help explain this observation.

Epidemiological studies are also needed to determine the timing of eruption of premolars and the prevalence of agenesis of the tooth buds of premolars. Radiographic examinations in clinics reveal a high prevalence of agenesis of the second premolars.

Studies on the correlation between blood levels of vitamin D in infants and toddlers who live in various regions of our country, and the prevalence of hypomineralization and hypocalcification defects of teeth, may help explain the etiology of these lesions in children in Belarus.

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Bangladesh

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Background Information on Bangladesh

Bangladesh is a developing country in South Asia, with 163.6 million residents. It is the fourth most populated country in the world. More than 70% of people live below the poverty line (Hussain and Sullivan, 2013). The oral health care of the populace is still very poor and worse in rural than in urban areas (Sujon et al., 2016). There are ongoing efforts by dentists, non-governmental organizations and the World Health Organization to increase public awareness about oral health care.

Bangladesh is a "least developed country". Deep-seated and inherited extreme poverty, hunger, growing social and economic disparities, frequent political and civil unrest, and the daunting challenge of natural hazards are common in Bangladesh. However, in recent decades, Bangladesh has achieved great development as shown by the Human Development Index. Bangladesh's index has increased 81% in the last 30 years (Ahmed et al., 2011).

More than 40% of the total population of Bangladesh live below the national poverty line. The majority of respondents (32.26%) earn Tk. 150,001-250,000 per year, and 25.81% earn above Tk. 250,000 per year.

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Figure 1: Map of Bangladesh (adopted from web)

Most persons engaged in work and business are aware of family planning and the importance of pure drinking water (Ahmed et al., 2011).

The malnutrition rate of Bangladesh is amongst the highest in the world. The prevalence of under-5 malnutrition is 41%, and it is more than 54% for pre-school age children. More than 9.5 million pre-school age children are stunted, 56% are underweight, and more than 17% are wasted. The prevalence of underweight children ranged from 49.8% in Khulna to

64.0% in Sylhet. Sylhet also had the highest prevalence of stunting at 61.4%, and wasting at 20.9% (Majid, 1981).

Children in Bangladesh also suffer from high rates of vitamin deficiency, especially vitamin A, and zinc, iodine and iron deficiency (Abdullah and Zeidenstein, 1982). The rate of anemia is also increasing. Malnutrition among women is also widespread in Bangladesh; more than 50% of women suffer from chronic energy deficiency (Abdullah and Zeidenstein, 1982).

However, in the last few decades, Bangladesh has made remarkable improvements in health and nutrition: the prevalence of vitamin deficiencies is reducing and so has the prevalence of the six vaccine-preventable and diarrheal diseases. Malnutrition is gradually decreasing by 1-2% each year. The prevalence of malnutrition and vitamin deficiencies is still high.

Timing and Sequence of Emergence of Primary Teeth

The normal growth pattern of Bangladeshi children lags behind that of children in developed countries (Chowdhury et al., 1977). When the exact age of a child is not known, calculating an estimated age from the weight and height of a child in rural Bangladesh, where only one in every five children have the normal weight-for-height for their age, can be challenging (Chowdhury et al., 1977).

The only study on tooth eruption profiles of children in Bangladesh was conducted 40 years ago in a rural area (Khan and Curlin, 1978). The longitudinal study determined the timing of eruption of the primary dentition and involved 350 children who were examined every month while they were below the age of 1 year, then every 3 months. There was no significant difference in the eruption pattern by gender. There were however gender differences in the timing of tooth emergence. At the age of 8 months, there was no gender difference in the number of emerged teeth. However, from the age of 8 months to 21 months, the average number of emerged teeth for females was less than that for males after which differences were less distinct. The primary dentition completed three months later in females when compared to males at 48 months. Primary teeth emerged in a few children by 5 months. Females also started to erupt their teeth at a lower mean weight than males. The study concluded that the longest period for the complete development of the primary dentition was 48 months, which was longer than that observed in most developed and some developing countries. Table 1 shows the data on the number of teeth that emerged in male and female study participants by age. Socioeconomic status influenced the rate of dentition development for the first 21 months but not thereafter. Children with a low socioeconomic status had delays in their eruption timing during this period, and those with a high birth weight had an earlier eruption time. Eruption time was not affected by frequent sickness. There are no studies on the timing of eruption of the permanent dentition.

Table 1. Timing of emergence of the primary teeth (Khan and Curlin, 1978)

Age (Month)	Male (n)	Average number of teeth	Female (n)	Average number of teeth
4	82	0	83	0
5	80	0.04	82	0.02
6	77	0.22	78	0.06
7	77	0.39	79	0.30
8	77	0.73	84	0.64
9	73	1.59	78	1.15
10	72	2.49	76	1.80
11	76	3.50	78	2.70
12	78	5.45	77	4.84
15	79	8.66	75	8.55
18	79	12.65	77	11.96
21	80	15.35	80	15.00
24	89	17.13	73	17.16
27	87	18.53	70	18.63
30	83	19.35	70	19.43
33	79	19.71	67	19.76
36	75	19.88	65	19.88
39	67	19.96	59	19.92
42	65	19.98	55	19.91
45	64	20.03	52	19.90
48	63	20.00	48	20.08

Prevalence of Dental Hard-tissue Anomalies

Two studies have been conducted in Bangladesh on the prevalence of developmental dental anomalies of the dental hard tissues. The first was conducted by Nahar et al. (2015) and involved a review of the records of 200 randomly selected orthodontic patients. The patients' radiographs were analyzed for anomalies. The authors concluded that missing teeth were more common in females (65.5%) than in males (34.5%) and impacted teeth (42.0%) were more common in the age group 11-15 years. Also, the most commonly impacted tooth was the upper right central incisor, followed by the upper right canine, the upper left central incisor and the upper left canine.

Table 2. Prevalence of developmental dental anomalies in permanent dentition of Bangladeshi patients

Anomalies	Nahar et al. (2015)	Sujon et al. (2016)
Third molar agenesis	-	38.4%
Hypodontia	-	3.1%
Impacted canine	1%	1.6%
Impacted upper right central incisor	1.5%	-
Impacted upper left central incisor	0.5%	-
Peg-shaped lateral incisors	-	0.1%
Microdontia	-	0.7%
Dilacerations	-	0.3%

The results of the study by Nahar et al. (2015) were complemented by the study of Sujon et al. (2016), who studied 5,923 Bangladeshi patients' panoramic radiographs. They found a prevalence of third molar agenesis of 38.4%. This prevalence was significantly higher in females than in males ($p < 0.025$) and more prevalent in the maxilla than in the mandible ($p < 0.007$). The prevalence of other dental anomalies in the permanent dentition was 6.5%. Hypodontia was the most prevalent dental anomaly (3.1%), followed by impacted canine (1.6%), peg-shaped lateral incisors (0.1%), microdontia (0.7%) and dilacerations (0.3%). The study findings are summarized in Table 2 above.

Gaps and Recommendations

Dental hard-tissue anomalies play a significant role in general oral health care (Delwel et al., 2017). Being the fourth most populous country, Bangladesh has the potential to provide data of global forensic importance on tooth eruption and dental hard-tissue anomalies. There are no nationally representative data on dates of primary and permanent tooth eruption for Bangladesh. Nor are there data on the prevalence and types of developmental dental anomalies in the primary and permanent dentition. Studies that provide these data are urgently needed for this large population.

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Brazil

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Background Information on Brazil

Brazil is the largest country in both South America and Latin America, the fifth most populous nation and the fifth largest country in the world. It has a population of over208 million people that is multicultural and ethnically diverse. . The country has 26 states, the Federal District, and 5,570 municipalities. Brazil is an upper-middle income economy with the eighth largest gross domestic product in the world.

The Brazilian public health system, the Unified Health System, is managed and provided by all levels of government. It is the largest system of this type in the world. On the other hand, private healthcare systems play a complementary role. Public health services are universal and offered to all citizens of the country for free, including oral health treatment.

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Figure 1: A map of Brazil in relation to other countries in South America

Emergence of Primary and Permanent Teeth

Emergence of Primary Teeth: Logan and Kronfeld (1933) reported on the order of emergence of the primary teeth: lower central incisor, upper central incisor, upper lateral incisor, lower lateral incisor, upper first molar, lower first molar, upper canine, lower canine, lower second molar and upper second molar. Table 1 shows the report on primary tooth emergence in Brazilian children between 1972 and 2015. The findings corroborate the order reported by Logan and Kronfeld (1933) in the maxilla. The order differs slightly in the mandible, with the upper lateral incisors emerging before the lower lateral incisors. The report by Patrianova et al. (2010), however, aligned with the observations of Logan and Kronfeld (1933).

CI – LI – 1ºM – C – 2ºM (Logan and Kronfeld, 1933)
CI – LI – 1ºM – C – 2ºM (Patrianova et al., 2010)

Emergence of Permanent Teeth: In the permanent dentition, the sequence of tooth emergence is: lower first molar, upper first molar, lower central incisor, upper central incisor, lower lateral incisor, upper lateral incisor, upper first premolar, lower first premolar, upper second premolar, lower second premolar, lower canine, upper canine, lower second molar and upper second molar (Logan and Kronfeld, 1933). Table 2 highlights the studies on the sequence of permanent teeth emergence in Brazilian children from 1971 to 2003. These studies show that the lower canine emerges after the first premolar, thereby differing from the observation of Logan and Kronfeld (1933).

1ºM – CI – LI – **C lower** – 1ºPM – 2ºPM – C upper – 2ºM (Logan and Kronfeld, 1933).
1ºM – CI – LI – 1ºPM – **C lower** – 2ºPM – C upper – 2ºM (Brazilian authors)

Factors that impact on the chronology of tooth emergence include hereditary, ethnic, environmental, systemic and local factors. Gender is one of the most-mentioned factors, but the evidence regarding its impact is mixed. Tamburus et al. (1977) concluded that tooth emergence begins earlier in girls than in boys, whereas Haddad (1997) found that emergence begins slightly earlier in boys, except for the upper central and lateral incisors. Patrianova et al. (2010) found that emergence of teeth 63, 72, 73 and 83 was earlier in boys than in girls, whereas emergence of the posterior teeth was earlier in girls than in boys. Terra (1999), on the other hand, found no significant differences between the mean age of tooth emergence of boys and girls. The author, however, observed that prematurity and low birth weight were associated with the later emergence of the primary teeth compared with the emergence time in full-term children, particularly for upper incisors and the upper and lower second molars. These studies were all cross-sectional in design, except for two that were longitudinal: Silveira (2000) and Ferreira et al. (2015). The longitudinal studies give more reliable data.

Table 1: Mean age (in months) of the sequence and chronology of eruption of deciduous teeth in Brazilian children

Teeth	Sex	Vono 1972 (SP)*	Tamburus 1977 (SP)**	Menezes 1983 (SP)*	Aguirre 1988 (SC)*	Haddad 1997 (SP)*	Terra 1999 (MS)*	Silveira 2000 (RJ)**	Patrianova 2010 (SC)*	Ferreira 2015 (ES)**
71,81	M	8,00	9,59	8,00	7,60	8,16	8,25	6,82	12,13	8,1
	F	8,37	8,19	8,20	7,32	8,36	8,75	7,10	12,25	8,4
51,61	M	9,47	11,00	8,80	9,37	10,42	10,92	8,32	11,30	11,1
	F	10,37	10,46	10,00	9,87	11,36	11,23	8,46	12,75	11,6
52,62	M	11,21	12,25	10,40	10,28	12,39	11,78	10,22	12,13	12,8
	F	12,17	12,22	11,00	11,43	13,23	13,22	11,33	13,10	14,1
72,82	M	13,00	13,85	10,80	12,70	14,24	14,51	11,69	14,5	15,3
	F	14,03	13,08	11,20	12,71	13,96	14,36	12,73	13,39	15,8
54,64	M	15,62	16,11	16,30	15,09	16,50	16,44	16,15	18,79	19,4
	F	15,19	15,19	16,00	14,46	16,07	15,84	16,68	18,70	19,7
74,84	M	16,07	17,00	16,40	15,41	16,88	17,52	16,42	19,09	19,4
	F	15,85	15,44	16,70	14,57	16,43	16,65	17,21	18,57	19,9

Teeth	Sex	Vono 1972 (SP)*	Tamburus 1977 (SP)**	Menezes 1983 (SP)*	Aguirre 1988 (SC)*	Haddad 1997 (SP)*	Terra 1999 (MS) *	Silveira 2000 (RJ)**	Patrianova 2010 (SC)*	Ferreira 2015 (ES)**
53,63	M	18,18	18,98	18,80	18,25	20,26	19,33	18,35	23,48	20,5
	F	18,85	18,97	18,60	18,87	20,25	20,23	19,72	23,90	22,5
73,83	M	19,13	19,91	19,70	18,82	20,46	20,14	19,35	23,33	22,0
	F	19,48	19,42	19,90	19,35	20,98	20,85	22,33	24,60	22,7
75,85	M	25,67	26,23	24,60	26,07	27,20	27,59	26,11	30,01	28,5
	F	25,11	25,11	25,20	26,09	27,72	27,94	32,75	30,19	29,4
55,65	M	26,72	27,98	25,80	27,52	28,84	28,92	26,96	30,80	30,0
	F	26,41	26,51	26,30	27,35	28,84	29,12	33,87	28,85	31,6

*Cross-sectional studies; **Longitudinal studies; M, male; F, female; Brazilian States: SP (São Paulo); SC (Santa Catarina); RJ (Rio de Janeiro); MS (Mato Grosso Sul); ES (Espirito Santo)

Table 2: Mean age (in months) of the sequence and chronology of eruption of permanent teeth in Brazilian children

Teeth	Sex	Freitas, 1971 (Marília)*	Freitas, 1971 (Ribeirão Preto)* – SP)*	Souza-Freitas 1991 (Bauru)*	Cançado, 2003 (Bauru)*
36,46	M	5,88	6,03	5,11	6,34/6,41
	F	5,72	5,90	5,1	5,94/5,95
16,26	M	6,37	6,28	6,0	6,29/6,47
	F	6.12	6,15	6,0	6,24/6,15
31, 41	M	6,27	6,34	6,4	6,29/6,29
	F	5,97	6,02	6,2	6,08/6,02
11, 21	M	7,39	7,15	7,2	7,07/7,07
	F	7,05	6,96	7,0	6,39/6,59
32, 42	M	7,39	7,33	7,2	7,39/7,33
	F	7,20	7,09	7,0	6,75/6,75
12, 22	M	8,59	8,31	8,2	8,14/8,20
	F	8,25	8,03	8,0	7,69/7,76
14, 24	M	10,24	9,89	9,9	10,00/9,70
	F	9,77	9,41	9,7	9,75/9,68

Teeth	**Sex**	Freitas, 1971 (Marília)*	Freitas, 1971 (Ribeirão Preto)* – SP)*	Souza-Freitas 1991 (Bauru)*	Cançado, 2003 (Bauru)*
34, 44	M	10,49	10,25	9,11	9,98/10,22
	F	9,94	9,76	9,4	9,39/9,31
33, 43	M	10,80	10,42	10,2	10,42/10,35
	F	9,77	9,56	9,6	9,11/9,31
15, 25	M	11,04	10,69	10,6	10,46/10,61
	F	10,63	10,37	10,4	10,15/10,58
35, 45	M	11,29	11,10	10,7	10,80/10,95
	F	10,75	10,72	10,4	10,63/10,14
13, 23	M	11,67	11,36	11,5	11,35/11,00
	F	11,02	10,74	10,7	10,66/10,46
37, 47	M	11,83	15,54	11,8	11,30/11,10
	F	11,13	11,10	11,3	10,75/10,66
17, 27	M	12,39	12,08	12,3	11,63/11,59
	F	11,98	11,77	11,5	11,23/11,10

*Cross-sectional studies carried on in São Paulo State

Prevalence of Developmental Dental Hard-tissue Anomalies

Dental anomalies are rarely detected during routine dental examination; they are often diagnosed, though, through clinical examination and complementary radiographic examinations. Even though most anomalies do not cause symptoms, they can lead to clinical problems including delayed or non-eruption of teeth, attrition, breastfeeding problems, compromised esthetics, occlusal interference, accidental cusp fracture, interference with the tongue space, difficulty in speech and mastication, temporomandibular joint pain and dysfunction, malocclusion, periodontal problems due to excessive occlusal force, post-eruptive tooth breakdown, and increased susceptibility to caries.

In primary dentition, the reported prevalence of dental anomalies in Brazil has ranged from 1.8% to 2.5%. The most common dental anomaly is double teeth, which was not found to have gender differences in its presentation (Kramer et al., 2008; Gomes et al., 2014).

In the mixed dentition, dental anomalies such as microdontia of the maxillary lateral incisors, mandibular second premolar disto-angulation, or primary molar infra-occlusion are often diagnosed during early mixed dentition, with an approximate 2.5-fold increased risk of developing palatally displaced canines during late mixed dentition compared with the risk in children without dental anomalies. These anomalies must be carefully monitored during the critical age for early diagnosis and intervention to prevent ectopic eruption of the maxillary canines (Garib et al., 2016).

Anomalies of the permanent dentition in Brazil are strongly associated with anomalies in the primary dentition (Nik-Hussein et al., 1996). Anomalies on the succedaneous permanent teeth were found in more than half of children to have affected the primary dentition. For example, it was estimated that all children with maxillary tooth agenesis in the primary dentition also had agenesis of the permanent succedaneous teeth (Gomes et al., 2014).

Dental abnormalities were found in 29% of Brazilian children who underwent chemotherapy, a percentage that is significantly higher than that in the healthy population. Among the anomalies, taurodontism was the most prevalent (14%). Children who received chemotherapy and radiotherapy doses greater than 2,200 cGy before the age of 5 had the highest rates of dental abnormalities (Lopes et al., 2006).

Anomalies of tooth number and tooth size: A frequent dental anomaly found in Brazilians is hypodontia, which is most often associated with retained primary teeth. Excluding third molars, the reported prevalence of hypodontia ranges from 1.6% to 6.9%, depending on the population studied (Al-Ani et al., 2017). The reported prevalence of hypoplasia in Brazil ranges from 0.2% to 21.2% in both dentitions (Table 3). A 6.3% prevalence of hypodontia was reported among Brazilian orthodontic patients, with the maxillary lateral incisors most frequently affected (Gomes et al., 2010). While missing teeth do not impact negatively on pre-school children's occlusion, they do impact negatively on the development of permanent teeth, resulting in the spacing or crowding of teeth, loss of arch length, midline deviation and delayed or ectopic eruption (Whittington and Durward, 1996; Gellin, 1984).

Another important dental anomaly that has been investigated in Brazilian children is supernumerary teeth; a prevalence between 0.2% and 6.7% has been reported as shown in Table 1. Consequences of this anomaly may be late eruption of the permanent tooth; non-eruption of the permanent tooth; prolonged retention of the primary teeth; displacement of teeth; formation of diastemas; and mal-positioning of the adjacent teeth. However, supernumerary teeth may have no associated consequences for the dentofacial complex, although they may cause rotation, root resorption and crown resorption of the adjacent permanent teeth (Gomes et al., 2008). Less frequent complications are ectopic eruption and pain (Primo et al., 1997; Lara et al., 2013). Most of the lesions were reported in 9- and 10-year-old patients. Multiple anomalies may occur together (Miziara et al., 2008). These include supernumerary teeth associated with tooth agenesis, ectopic eruptions and microdontia.

Table 3. Prevalence of hard dental tissue anomalies in Brazilian children and adolescents

	Dental anomaly	Age	Prevalence	Author(s)
TOOTHNUMBER	**Hyperdontia (Supernumerary tooth)**	2-14 2-5 7-14 6-12 4-14 6-20 1-12 2-5	2.9% 0.3% 2.3% 2.3% 1.7% 1.7% 6.7% 0.2%	Primo et al., 1997 Kramer et al., 2008 Miziara et al., 2008 Küchler et al., 2011 Simões et al., 2011 Freitas et al., 2012 Gonçalves-Filho et al., 2014 Gomes et al., 2014
TOOTHNUMBER	**Hypodontia (Tooth agenesis)**	2-5 7-14 10-15 6-12 6-20 1-12 2-5 7-10	0.6% 1.2% 6.3% 4.6% 9.1% 11.1% 0.2% 21.2%	Kramer et al., 2008 Miziara et al., 2008 Gomes et al., 2010 Küchler et al., 2008 Freitas et.al., 2012 Gonçalves-Filho et al., 2014 Gomes et al., 2014 Pedreira et al., 2016
SHAPE	**Double Teeth (Fusion or Gemination)**	2-5 6-20 2-5	1.3% 0.2% 0.9%	Kramer et al., 2008 Freitas et al., 2012 Gomes et al., 2014
SHAPE	**Concrescence**	6-20	0.2%	Freitas et al., 2012
SHAPE	**Dilaceration**	1-12	4.9%	Gonçalves-Filho et al., 2014
SHAPE	**Talon cusp**	1-12	3.0%	Gonçalves-Filho et al., 2014
SHAPE	**Dens in dente**	1-12	0.6%	Gonçalves-Filho et al., 2014
SHAPE	**Taurodontism**	<12 years old 6-12 6-20 1-12 7-10	14% 1.6% 0.2% 38.2% 2.2%	Lopes et al., 2006 Küchler et al., 2008 Freitas et al., 2012 Gonçalves-Filho et al., 2014 Pedreira et al., 2016

	Dental anomaly	Age	Prevalence	Author(s)
SIZE	**Peg-shaped tooth**	1-12	4.9%	Gonçalves-Filho et al., 2014
	Dens in dente	1-12	0.6%	Gonçalves-Filho et al., 2014
	Microdontia	<12 years old 2-5 6-20 1-12 2-5 7-10	7.0% 0.3% 1.3% 2.4% 0.1% 31.5%	Lopes et al., 2006 Kramer et al., 2008 Freitas et al., 2012 Gonçalves-Filho et al., 2014 Gomes et al., 2014 Pedreira et al., 2016
	Macrodontia	<12 years old 1-12 7-10	5.0% 0.6% 5.6%	pes et al., 2006 Gonçalves-Filho et al., 2014 Pedreira et al., 2016
POSITION	**Impaction**	7-10	24.7%	Pedreira et al., 2016
	Ectopia	7-14 7-10	0.6% 29.2%	Miziara et al., 2008 Pedreira et al., 2016
	Transposition	8-15 7-10	0.3% 2.2%	Costa et al., 2010 Pedreira et al., 2016
STRUCTURE	**Amelogenesis Imperfecta**	1-12	1.2%	Gonçalves-Filho et al., 2014
	Fluorosis	6-15 7-12 11-12 12 5-15 12 12 12 12-18	18.3% 3.0% 15.7% 17.1% 8.1% 36.2% 5.6% 29.4% 30.2%	Michel-Crosato et al., 2005 Bardal et al., 2005 Meneghim et al., 2006 Hoffmann et al., 2007 De Carvalho et al., 2010 Rigo et al., 2010 Freire et al., 2010 Benazzi et al., 2012 Almeida et al., 2013
	Enamel hypoplasia	7-14 1-12	3.5% 0.6%	Miziara et al., 2008 Gonçalves-Filho et al., 2014

	Dental anomaly	Age	Prevalence	Author(s)
STRUCTURE	**Defects of developmental enamel**	3-5 1-36 16 and 18 months 3-5 years 2-5 2-5 6-11 2-4	24.4% 25.1% 49.6% 29.9% 33.9% 39.1% 6.48% HSPM*, 2.22% HPC** 47.6%	Lunardelli & Peres, 2005 Oliveira et al., 2006 Massoni et al., 2009 Corrêa-Faria et al., 2013 Corrêa-Faria et al., 2015 Massignan et al., 2016 da Silva Figueiredo Sé et al., 2017 XCarvalho et al., 2018
	Molar-incisor hypomineralization (HMI)	7-13 6-12 6-12 6-12 6-10 11-14 8-9 11-14 6-11 8-15	40.2% 19.8% urban area 17.8% rural area 24.9% 12.3% 9.1% 18.4% 20.4% 18.9% 14.69% 29.3%	Soviero et al., 2009 da Costa-Silva et al., 2010 Souza et al., 2012 Jeremias et al., 2013 Hanan et al., 2015 de Lima et al., 2015 Tourino et al., 2016 Dantas-Neta et al., 2016 da Silva Figueiredo Sé et al., 2017 Teixeira et al., 2018

*HSPM – hypomineralization second primary molar; **HPC – hypomineralization primary canine; XPaper in submission

Associations suggest a common genetic origin. Garib et al. (2016) reported that tooth agenesis, microdontia, primary molar infra-occlusion and ectopic eruptions are products of the same genetic mechanism that causes second-premolar agenesis. Tooth agenesis is, however, not associated with taurodontism in Brazilian children, whereas it has been reported in other countries (Seow and Lai, 1989).

Anomalies of tooth position: The prevalence of dental transposition is 0.3% in Brazilian children aged 8 to 15 years (Table 1). This anomaly may result from hereditary factors, prolonged retention of primary teeth, or trauma. In 75% of the cases, an association between dental anomalies such as tooth rotation, early tooth loss, over-retention of primary teeth and tooth impaction was found (Costa et al., 2010). Tooth ectopia and tooth impaction mainly affected the upper canines, often resulting in occlusal maladjustments that may interfere with orthodontic treatment (Pedreira et al., 2016). Orthodontic patients presenting with impactions have a higher prevalence of Class III malocclusion than those patients who do not have impactions (Pedreira et al., 2016).

Anomalies of tooth shape: Taurodontism was the most frequent tooth-shape-related dental abnormality found among children and adolescents in Brazil, with a prevalence of 0.2% to 38.2% (Table 3). These tooth-shape anomalies tend to cause less dental impairment than other anomalies, and many do not require specific treatment (Gonçalves-Filho et al., 2014).

Anomalies of tooth structure: Few Brazilian studies on the prevalence of anomalies related to tooth structure have been published (Table 1). In a retrospective study with panoramic radiographs, 1.2% of 478 children had tooth-structure anomalies (Gonçalves-Filho et al., 2014). One of the abnormalities is amelogenesis imperfecta, which is associated with tooth sensitivity, loss of vertical dimension, enamel deficiencies, pulp calcification, esthetic concerns (Aldred et al., 2003), failed tooth eruption, and impaction of permanent teeth (Aldred et al., 2003; Suchancova et al., 2014). The severe form of amelogenesis imperfecta is also associated with the failure of emergence of multiple permanent teeth (Fritz, 1981; Williams and Ogden, 1988; Ooya et al., 1988). Seow (1995), reported that patients with amelogenesis imperfecta were six times more likely than unaffected people to have impaction of the permanent teeth and associated anomalies such as follicular cysts.

Another rare dental anomaly involving hard-tissue structure is dentinogenesis imperfecta (Yassin, 2016), but no cross-sectional or longitudinal studies have been published about this anomaly in Brazilians.

Dental fluorosis affects Brazilian children. The prevalence and severity of fluorosis in 11-12-year-old Brazilian schoolchildren increased between 2000 (Brasil, 2001) and 2010 (Brasil, 2011). In 2000, the prevalence was 8.6% (6.2% very mild; 1.7% mild; 0.5% moderate and 0.2% severe).

However, in 2010, the prevalence was 16.7% (10.8% very mild; 4.3% mild; 1.6% moderate and none severe).

The reported prevalence of molar-incisor hypomineralization varies between 9.12% and 45.5% (Hanan et al., 2015: Andrade et al., 2017), as highlighted in Table 1.

Gaps and Recommendations

Because dental anomalies can be inherited, a family history and early clinical diagnosis or radiographic detection can alert parents and clinicians of the high probability of other anomalies being present in the same person, and similar anomalies being present in other members of the family. However, routine family screening for dental anomalies is not an institutionalized practice in Brazil; it should be instituted into the patients' clinical management. Screening is more needed in children who present with bilateral dental anomalies in the primary dentition, as this presentation increases the likelihood of the anomaly occurring in the succedaneous permanent teeth. Thus, the importance of identifying dental anomalies in the primary dentition is clear.

The detection of anomalies with a prevalence as low as 1% demands the study of larger population samples. We need more longitudinal studies to enable comparisons between populations from various regions of Brazil. Large population studies will also help identify, with greater reliability, possible factors associated with dental-emergence anomalies in the primary and permanent dentitions.

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Chile

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Background Information on Chile

Chile is a developing country in southwest South America, situated between the Andes and the Pacific Ocean. It is more than 4,000 km long and less than 200 km wide. Chile has about 18 million inhabitants, life expectancy is nearly 80 years, and the literacy rate is 98.5% (INE, 2006).

Chile has three distinct geographical areas: the north, which has the driest desert in the world; the center, with a Mediterranean climate, which is home to 80% of the population; and the south, which has cold and rainy weather. Eighty-five per cent of Chile's population reside in urban areas (INE, 2006). The country has 15 governmental regions, each with a regional government (Figure 1). Access to healthcare is guaranteed to all citizens, and medical care and dental care are provided to more than 80% of the population (MDS, 2013).

The geographic, socioeconomic, and cultural realities vary throughout the country. Some areas have marked ethnic differences, and, as a result, they have dissimilar perceptions and behavior towards dental care. Local geography and economics also affect access to oral- health benefits.

Several studies have examined the settlement, migration and mixture of cultures in South America, but few have used data on dental features for these purposes (Sutter, 2006; Fonseca, 2016).

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Figure 1. Map of Chile.

*Ethnic group***:** The racial composition of the Chilean population is simple; in 1965 it included only Caucasoid and Amerindian components. A study on Diaguita indigenous people of the X century found an 80.3% frequency of shovel-shaped incisors and absence of the cusp of Carabelli (Campusano, 1972). In a village near Temuco, where ethnically and culturally different Mapuche and non-Mapuche groups live, the mesial tergiversions of the maxillary central incisors and shovel-shaped incisors are hard dental-tissue features that distinguish these groups (Palomino, 1971).

Residents in the city of Santiago were evaluated genetically according to serological markers such as ABO and Rh blood groups (Palomino, 1995). A socio-genetic gradient was established; this revealed that persons of higher socioeconomic levels (private) had mostly Caucasian genes, whereas those of lower socioeconomic levels (public) had more indigenous genes (Palomino, 1995). The distribution of shovel-shaped incisors and the mesial tergiversion of the maxillary central incisors in the Chilean population depends on factors such as geographical location, level of isolation, racial components, and gender ratio (Palomino, 1995). Individuals from "public Santiago" have a higher frequency of a shovel-shaped tooth (70%) and a lower frequency of Carabelli's tubercle (7.5%) than individuals from "private Santiago" do (52.5% and 20%, respectively). The dental features of "public Santiago" are closer to those of indigenous Chileans: 83% have shovel-shaped teeth, and 7.2% have Carabelli's tubercle (Palomino, 1995). A shovel-shaped tooth was also the most prominent oral feature present in a mixed-blood population in Chile studied in 1966 (Rivera, 2012).

Timing and Sequence of Emergence of Primary and Permanent Teeth

Studies on tooth emergence in Chile are outdated and do not reflect recent changes in the child population. A study conducted in 1978 determined the dates of primary teeth emergence in a sample of 700 children, aged 3 months to 6 years (5% of live births), who resided in the north area of Santiago (Cisternas, 1978). Table 1 illustrates the eruption and exfoliation dates for their primary dentition.

Table 1. Emergence and exfoliation age of primary teeth

	Teeth	Eruption date Mean (age range)	Exfoliation date Mean (age range)
Maxillary	Central incisor	7-12 months	6-8 years
	Lateral incisor	9-13 months	7-8 years
	Canine	16-22 months	10-12 years
	First molar	13-19 months	9-11 years
	Second molar	25-33 months	10-12 years
Mandibular	Central incisor	6-10 months	6-8 years
	Lateral incisor	7-16 months	7-8 years
	Canine	16-23 months	9-12 years
	First molar	12-18 months	9-11 years
	Second molar	20-31 months	10-12 years

Pavic (1992) conducted a study with 187 children, aged 8 to 12 years, in the Metropolitan region. He observed that the timing of emergence of the canines and premolars in males was similar to that reported in the international literature. However, the time of emergence of the same teeth in females was earlier, as reported in an earlier study conducted in the same region (Gonzalez, 1998). Table 2 illustrates the dates of emergence of the mandibular and maxillary canines and premolars. In the maxilla, the first and second premolars emerged before the canine. In the mandible, however, the canine emerged before the first and second premolars. In males, a second variant of emergence was noticed – the first premolar emerged before the canine, and the second premolar emerged after the canine. The second permanent molar emerged before the second premolar in 6% of females and in 20.5% of males (Pavic, 1992).

Table 2. Age of emergence of canines and premolars

	Tooth	Maxillary (Range)	Mandibular (Range)
Boys	Canine	11.5-12.0 years	10.5-10.5 years
	1st PM	10.0-10.5 years	10.0-10.5 years
	2nd PM	11.5-12.0 years	11.0-11.5 years
Girls	Canine	10.5-11.0 years	9.5-10.0 years
	1st PM	9.5-10.0 years	9.5-10.0 years
	2nd PM	10.5-11.0 years	10.5-11.0 years

In a study conducted of 5-8.5-year-old children in the Metropolitan region, the dates of emergence of the first permanent molars were between 6.1 and 6.5 years in males and 5.6 and 6.0 years in females (Said, 1999). The mandibular first permanent molars emerged before the maxillary first permanent molars and the mandibular central incisors for both genders. The permanent maxillary central and permanent mandibular lateral incisors emerged at 7 and 8 years of age, respectively (Said, 1999). In the X region, 65% of the first permanent molars had emerged and 7% had partially emerged in 6-year-old children (Zaror, 2011).

A study of orthopantomograms of 500 children, aged 6 to 9 years, in the Metropolitan region revealed that 4.0% of third molars erupted ectopically (Aguirre, 2012). Whereas, a review of 536 orthopanthomographs of children, aged 7 to 10 years, in Viña del Mar, found that 0.74% of third molars erupted ectopically (Karime, 2016).

Tooth Agenesis

In a study conducted in the Metropolitan region, the frequency of tooth agenesis, exclusive of the third molar, was 5.75% (Chappuzeau, 2008). Females were affected more than males, with a ratio of 1.1:1. The most common missing tooth was the mandibular second premolar, and bilateral agenesis occurred more often than unilateral agenesis (Chappuzeau, 2008).

A similar profile was reported for children, aged 6 to 11 years who resided in Temuco: the prevalence of dental agenesis was 4.2%; females were more affected than males; and the mandibular second premolar was most affected, followed by the maxillary second premolar and the mandibular lateral incisor (Pineda, 2011). In Viña del Mar, the frequency of tooth agenesis in children, aged 7 to 10 years, was 7%; the mandibular second premolar was most affected, followed by the maxillary lateral incisor (Karime, 2016).

Supernumerary Teeth

In a study of orthopanthomographs of patients, aged 10 to 30 years, who resided in the Metropolitan region, the prevalence of supernumerary teeth was 3.4% (Sanchez, 2013). Males were more affected than females, with a ratio of 1.3:1. Sixty-eight per cent of patients had dysmorphic supernumerary teeth; 82% had only one supernumerary tooth. Also, 81% of supernumerary teeth were located intraosseously, with 74% in the maxilla. The mesiodens was the supernumerary tooth most frequently (36%) identified (Sanchez, 2013). An earlier study by Chappuzeau (2008), conducted in the Metropolitan region, found a prevalence of 2% for supernumerary teeth. All the supernumerary teeth identified were in the maxilla. Men were more affected than women, with a ratio of 1.25:1. Karime (2016) reported a prevalence of 4.8% in a study of children in Viña del Mar.

Table 3. Frequency of agenesis and supernumerary teeth

Study location (author, year)	Number of subjects	Agenesis	Supernumerary
		%	%
Metropolitan Region (Chappuzeau, 2008)	452	5.7	2.0
Temuco (Pineda, 2011)	307	4.2	-
Metropolitan Region (Sánchez, 2013)	1.288	-	3.4
Viña del Mar (Karime, 2016)	539	7.0	4.8

Developmental Defects of Enamel

A genetic, clinical, and radiographic study of developmental defects of enamel diagnosed between 2010 and 2015 by the Faculty of Dentistry, University of Chile, determined that the prevalence of defects was low, and all were variants of amelogenesis imperfecta (Vivanco, 2016). Another study, of 1-3-year-old children with special needs at the Teleton Maule Institute, Talca, reported a prevalence of 94.3% (Poblete, 2012).

Molar Incisor Hypomineralization: Table 4 presents a summary of studies conducted on molar incisor hypomineralization in Chile. The first study, published in 2010, involved children, aged 6 to 10 years of age who resided in the VII region (Vallejos, 2010). The prevalence of hypomineralization was 14.1%, and the prevalence was higher in females than in males (19% vs. 11%). Also, 60% of the cases involved the incisor, and 79% of affected teeth had mild lesions. The average number of teeth affected was 5.4 per child, and the average number of molars affected was 3.63. The teeth most affected were the left and right mandibular molars while the least affected was the left lateral incisor (Vallejos, 2010). Several subsequent studies on molar incisor hypomineralization in several populations in Chile found similar results.

In San Bernardo, in the Metropolitan region, the prevalence of molar incisor hypomineralization in children, aged 8 to 12 years, was 11.4% (Zambrano, 2011). There was no significant gender difference in prevalence or severity, but the lesion was more prevalent in the maxilla. In children with molar incisor hypomineralization, the incisor was involved in 89.3%. The most commonly affected teeth were the first permanent molar, left and right, and the lower left first molar permanent (Zambrano, 2011).

The prevalence of molar incisor hypomineralization in children, aged 6 to 12 years, in the Metropolitan region was 12.7% in 2015 (Matute, 2015). Two years later, Sarquis (2017) found a prevalence of 12.8% for children of the same age from the same region. The prevalence was highest among 8-9-year-old children, and no gender difference was observed (Matute, 2015). The prevalence of mild, moderate, and severe molar incisor hypomineralization was 42.6%, 27.8% and 29.6% respectively (Leiva, 2015). As the severity increased, more teeth were affected (Leiva, 2015). For school children from Santiago of the same age, the prevalence of the lesion was 12.8% (Catalán, 2016). The mild form was the most prevalent (Catalán, 2016).

Fariña (2014) showed that the prevalence of hypomineralisation was higher in rural than in urban areas. His study of 7-9-year-old children who resided in the urban and rural areas of San Clemente, in the VII region, revealed that the prevalence of molar incisor hypomineralization was 14.9% in the urban area and 24.3% in the rural area. The prevalence of the moderate form of the lesion was highest (74.6%), and moderate lesions were more prevalent in urban than in rural areas (81% vs. 71.4%).

In contrast to the studies mentioned above, the results of a hospital-based study differed significantly. In 2011, a study was conducted at the Universidad de la Frontera, Temuco (Jans, 2011). Children, aged 6 to 13 years, were recruited, and 16.8% had molar incisor hypomineralization; 57% had severe lesions, 20% had moderate lesions and 23% had mild lesions. There were no significant age or gender differences in the prevalence or severity of the lesions (Jans, 2011). The prevalence was even higher (27%) for children with special needs who attended the Hospital of Curicó, VII Region (Jiménez, 2015). The prevalence of mild, moderate, and severe lesions was 15%, 45%, and 40%, respectively.

Molar incisor hypomineralization is associated with oral lesions. Rodriguez (2015) reported that school children, aged 6 to 12 years, from Metropolitan region schools who had molar incisor hypomineralization had a higher DMFT and deft index than those without hypomineralization. This finding was corroborated by Sarquis (2017).

Risk factors identified for molar incisor hypomineralisation include premature birth, childbirth complications, low birthweight, breastfeeding less than 6 months, otitis, asthma and antibiotic intake (Tapia, 2012). Also, 87% of children with molar incisor hypomineralization had a history of medical complications in the prenatal to early infancy time (Jans, 2011). Catalán (2016) found a statistically significant association between the prevalence of hypomineralisation and low socioeconomic status (Catalán, 2016).

Fluorosis: Chile pioneered the fluoridation of drinking water in Latin America, a process that started in 1953 in the VII region and spread throughout much of the country. Water fluoridation was suspended in 1977 (MINSAL, 2008; Gómez, 2010). A national survey of the fluoride

Table 4: Prevalence and severity of molar incisor hypomineralization by location of the study and author

Location (author, year)	Prevalence (%)	Severity (%)
VII Region (Vallejos, 2010)	14.1	Mild – 79.0
Temuco (Jans, 2011)	16.8	Mild – 23.0 Moderate – 20.0 Severe – 57.0
San Bernardo (Zambrano, 2011)	11.4	-
VII Region (Fariña, 2014)	20.1	Moderate – 74,6 (81% in urban area and 71.4% in rural area)
VII Region (Jiménez, 2015)	27.0	Mild – 15.0 Moderate – 45.0 Severe – 40
Metropolitan Region (Leiva, 2015)		Mild – 42.6 Moderate – 27.8 Severe – 29.6
Metropolitan Region (Sarquis, 2017)	12.8	-

content of natural water sources in urban areas showed that 87.9% of Chile's population was supplied with water containing 0.00-0.30 ppm of fluoride, 7.8% with 0.30-0.75 ppm of fluoride, and 4.2% with more than 0.75 ppm of fluoride (Guerrero, 1983). In view of this finding, water fluoridation in the V region was resumed in 1985, and it has been scaled up to that of other regions since 1999 (MINSAL, 2008; Verena, 2017). It is currently estimated that 82.0% of the nation's urban population, covering 14 of the 15 regions of the country, is supplied with fluoridated drinking water (MINSAL, 2018). Because of opposition from the community, the VIII region does not receive fluoridated drinking water. An increase in the prevalence of low-degree dental fluorosis has been observed in Temuco. In rural schools in communities where the level of fluoride in water is low, fluoridated drinking water is complemented by fluoridated milk, a practice that has been ongoing since 2000 (Guerrero, 1983; Ballesteros, 2004; Yévenes, 2011). Regulations on the use of fluoridated toothpaste changed in Chile in 2016: toothpastes containing less than 1000 ppm of fluoride are not allowed for children less than six years of age (MINSAL, 2015).

In Chile, few studies have investigated the impact of water fluoridation on the population's oral health. Using the Dean Index, Urbina (1997) evaluated dental fluorosis in six regions of Chile and found that the prevalence of endemic fluorosis was 15.2% (Urbina, 1997). Others have identified increases in the prevalence of dental fluorosis after the institution of water fluoridation: In Temuco, the prevalence of dental fluorosis was 3.1% before the fluoridation of the water supply; it increased to 53.0% eight years after water fluoridation (Ballesteros, 2004). Similarly, in the Metropolitan region, the prevalence of dental fluorosis was 4.2% before fluoridation of the water supply and 32.2% eight years after fluoridation (Yévenes, 2011).

In 2012, a pilot study involving school children residing for at least six years in places with various concentrations of fluoride showed a national dental fluorosis prevalence of 54.0% (Olivares, 2013). The National Diagnosis of Oral Health of 12-year-olds, conducted in 2007, showed that 31.2% of children had mild or very mild degrees of dental fluorosis. The region that had the highest prevalence of the lesion was the V region, where 60.2% of the population was affected. A significant proportion of those affected with fluorosis may be unaware of the lesion because of its questionable/very mild/mild presentation (Soto, 2007; Gómez, 2010). The increased prevalence of dental fluorosis has been matched with a decreased prevalence and severity of dental caries in children and adolescents (Olivares-Keller, 2013; Verena, 2017; MINSAL, 2018). Table 5 presents the profile of dental fluorosis in children, aged 12 years, in the regions of Chile.

Gaps and Recommendations

Oral health research in Chile has focused mainly on the prevalence of caries, gingivitis and dental anomalies. There are no previous publications on fluorosis before 2007. Research on molar incisor hypomineralization has been limited largely to regions of the country that host the main Faculties of Dentistry. Studies on tooth eruption are limited and date back to 1992. There is only one clinical case report on anomalies of shape and size, and there is no epidemiologic survey. The Ministry of Health should

Table 5. Prevalence of fluorosis by region and severity in 12-year-olds (Soto, 2007)

Region	Normal (%)	Questionable (%)	Very mild (%)	Mild (%)	Moderate (%)	Severe (%)
I	60.3	17.5	17.5	4.8	0.0	0.0
II	48.4	32.8	17.2	1.6	0.0	0.0
III	60.0	22.0	16.0	2.0	0.0	0.0
IV	77.6	15.3	5.9	1.2	0.0	0.0
V	39.8	15.2	39.3	4.3	1.4	0.0
VI	81.3	11.4	7.3	0.0	0.0	0.0
VII	78.5	13.4	6.0	2.0	0.0	0.0
VIII	74.5	15.4	8.0	2.1	0.0	0.0
IX	84.1	7.1	6.3	1.6	0.8	0.0
X	73.5	19.8	6.2	0.6	0.0	0.0
XI	72.9	18.8	8.3	0.0	0.0	0.0
XII	65.3	20.4	14.3	0.0	0.0	0.0
MR	69.3	13.0	13.5	3.6	0.5	0.1
Total	**68.8**	**14.9**	**13.4**	**2.5**	**0.4**	**0.0**

conduct an oral-health survey to determine the prevalence of developmental dental hard-tissue anomalies. Also, coordinated multicenter studies, conducted by universities, could provide representative data on developmental dental hard-tissue anomalies for the country. The new 2012 law 20584 that regulates research on human beings makes it more difficult and challenging to conduct studies with human beings. While developmental dental anomalies may not be seen as lesions with public health importance, they should be given due consideration since they can significantly affect dental function, esthetics, and even mental health.

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EGYPT

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Background Information on Egypt

Figure 1 is a map of Egypt. Egypt lies in Northern Africa. It has a presidential republic style of government with 27 administrative units known as governorates (Central Intelligence Agency, 2017). The concentration of fluoride in drinking water ranges from 0.49-0.53 mg/l in West District, Alexandria, to 0.8-0.9 mg/l in Borg El-Arab, Alexandria (Aboulazm, 2005). In Saint Katherine, Sinai, wells are the major source of drinking water and have high fluoride concentrations (0.9-.004 ppm). The concentration of fluoride in bottled drinking water is low (0.19 ppm). Fluoride tablets and supplements are sold in pharmacies. Only 1% of 2-5-year-old children have ever received professional fluoride application, and 2.9% use fluoride tablets (El Tantawi et al., 2018). In 2016, Egypt was ranked seventh in the world in annual per capita tea consumption, at a rate of 2.3 pounds per person (Statistica, 2016). Black tea contains about 3.4 ppm fluoride (Whyte, 2006).

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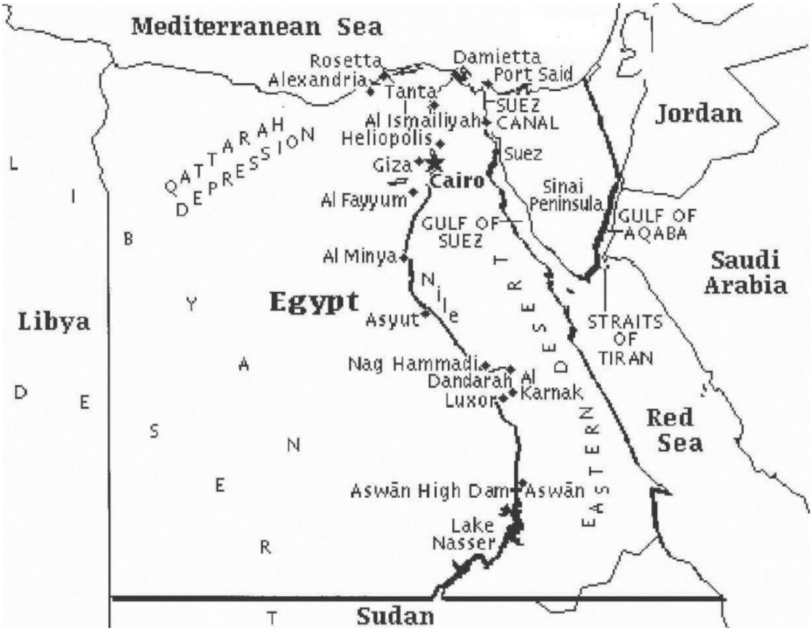

Figure 1: Map of Egypt

Emergence of Primary and Permanent Teeth

Emergence of primary teeth: Studies on the emergence profile of the primary teeth in Egyptian children are highlighted in Table 1. The first tooth to emerge is the mandibular central incisor at 7.8 months, and the last to emerge are the maxillary and mandibular second molars. The first teeth emerge earlier in boys than in girls. However, there is no difference between boys and girls in the emergence time for the last teeth. Teeth emerged earlier in children who took vitamin supplements than in those who did not (El-Hadary and El-Nesr, 1976).

Maxillary teeth erupted before mandibular teeth, except for the central incisor and the second molar (Karam, 1987; El-Beheri, 1987). While Karam (1987) found no difference in eruption dates of teeth on the right and left sides, El-Batran et al. (2002) reported that teeth on the left side erupted earlier than their antimeres. In the most recent study, boys and girls had the same dates of eruption for all teeth, except for the second molar, which erupted earlier in boys than in girls (Soliman et al., 2011).

Emergence of permanent teeth: Mahdly (1990) reported that the first molar was the first tooth to emerge, at 5.8 years, in boys and girls. The mandibular anterior teeth and mandibular first molar emerged before their maxillary counterparts. The maxillary posterior teeth – premolars and molars – emerged before their mandibular counterparts. In most cases, eruption was earlier in girls than in boys. The first molar erupted before other teeth in both arches for boys and girls (Abd El-Hakam, 2015) with variations in emergence dates. Intellectual disabilities due to chromosomal and single-gene defects were associated with delayed eruption (Ramzy et al., 2003). Table 2 provides a summary of the emergence profile of the permanent dentition.

Dental maturity: The estimation of dental age for legal and forensic purposes, by use of the Demirjian method, was found to be not applicable to Egyptian children as the method overestimated the dental age when compared with their chronological age by 0.208 years for boys, and 0.294 years for girls (Azzawi et al., 2016). The Willems method for age estimation had an average overestimation of 0.14 years for girls and 0.29 years for boys. The Cameriere method resulted in an average underestimation of age by 0.26 years for girls and 0.49 years for boys (El-Bakary et al., 2010).

Prevalence of Hard Dental-tissue Anomalies

Population-based surveys showed that the prevalence of dental anomalies among primary school children in Alexandria was 15.3% (Ahmed, 1979) and 11.2% in Cairo (Lotfy, 2014). A clinic-based survey found a higher prevalence of dental anomalies in Egyptians – up to 32.6% (Montasser, 2012). It is difficult to identify which is the most prevalent type of anomaly since different methods were employed to identify them. Also, none of the studies included a nationally representative sample.

Anomalies of Structure and Shape

Fluorosis: Most studies assessing fluorosis in Egypt (Table 3) were on children; only two included adults. The prevalence of fluorosis ranged from 85.7% (Aboulazm, 2005) to 94.6% (Khalifa, 2015). The questionable/very mild/mild type of fluorosis was the most prevalent lesion. The prevalence was also higher in rural than urban areas, higher in maxillary than in mandibular teeth, and higher in premolars than in other teeth (Aboulazm, 2005). No studies assessed fluorosis in primary teeth.

There is mixed evidence about the association of fluorosis with the amount of fluoridated toothpaste used: some studies confirmed the association (Aboulazm, 2005; Ramadan, 2010), while a recent study found no association (Khalifa, 2015). There also was equivocal evidence about the positive association of fluorosis with the intake of foods, such as fish and chicken soup, and drinks, such as tea (Ramadan, 2010; Khalifa, 2015).

Enamel hypoplasia: Several studies have assessed the presence of anomalies in ancient Egyptian mummies. The presence of microscopic and large enamel defects was associated with growth disturbances. The prevalence was higher in permanent teeth, pointing to insults occurring at 3-5 years of age, than in primary teeth, resulting from physiological stresses in utero. The pattern of enamel hypoplasia differed in the primary and permanent teeth. The prevalence in both the primary and permanent dentition was 40% (Hillson, 1992). Such stresses could have reflected periods of drought and malnutrition in the Old Kingdom (Lovell et al., 1990).

In an early modern times survey, Wheatcroft (1959) reported a prevalence of 2.7% hypocalcification in individuals from Qalyub, near Cairo. In more recent population-based surveys, a prevalence of 0.97% was reported for enamel hypoplasia among 6-12-year-old children in the Delta area (Raghib, 1980). Also, a prevalence of molar incisor hypomineralization of 2.3% in children aged 8-12 years was reported. The molars were most frequently affected by molar incisor hypomineralization (Saber et al., 2018).

Table 4 is a summary of findings of studies on developmental enamel defects in Egypt. A higher prevalence of defects was reported in Damietta, ranging from 11.2% in 12-year-old children to 6.4% in 15-year-old children and 3.8% in 35-44-year-old adults (Salama, 2009). In clinic-based studies conducted in Cairo, the prevalence of enamel hypoplasia was 3.3% among 6-14-year-old children (Hawas, 2012; Lotfy, 2014).

Enamel hypoplasia and enamel hypocalcification were associated with 3-M syndrome in Egypt (Temtamy et al., 2006). Hypoplastic teeth were more prevalent in patients with Turner syndrome than in controls – 50% versus 30% (Ramzy, 1983); more prevalent in children with celiac disease than in children in the general population – 17.9% versus 1% (El-Hodhod et al., 2012); more prevalent in the permanent dentition of 9-12-year-old children with end-stage renal dialysis who were on hemodialysis (Salem, 2008); and more prevalent in children with intellectual disabilities due to chromosomal or single gene defects (Ramzy et al., 2003).

Dentine hypoplasia: No cases of dentinogenesis imperfecta were found in a survey of dental anomalies in 509 Egyptian patients (Montasser and Taha, 2012). A study of 49 osteogenesis imperfecta cases showed that 7.7%, 26.9% and 22.2% of type I, III and IV osteogenesis imperfecta respectively, had associated dentinogenesis imperfecta (Elnagdy, 2012).

Black stains: Table 5 lists the main features of studies reporting on black dental stains in Egyptian children. A clinic-based study conducted in the Ain Shams Faculty of Dentistry reported a prevalence of black stains of 1.8% (Sharaf, 2017). The stains were more common in 6-8-year-old children than in younger children, and in the mixed rather than the primary dentition (Ahmed, 2014). The stains were associated with respiratory problems, especially upper tract problems, in 4-8-year-old children (Ahmed, 2014) and were linked to *Actinomyces* in the supra gingival plaque of children with primary dentition; 23.8% of 3-5.5-year-old children had black stains (Negm, 2015). The stains were also associated with lower levels of phosphorous in saliva, intake of dairy products, and intake of iron supplements but not with oral hygiene status (Sharaf, 2017). Stains were adequately controlled by mechanical removal without the need for the use of fluoride or chlorhexidine (Negm, 2015).

Anomalies of Shape

Taurodontism was reported in ancient mummies of Egyptian children (Miller, 1918; Senyurek, 1939). Also, in 1,138 molars in Egyptian skulls, 8.6% of the teeth had cervical enamel projections associated with bone loss in the furcation area (Bissada and Abdelmalek, 1973). Although there are no population studies on the prevalence of taurodontism and cervical enamel projections, there are reports on the prevalence of other shape-related dental anomalies. The prevalence of peg-shaped lateral incisors was 22% among 14-30-year-old Egyptians from Cairo, with a higher prevalence in females than in males, and it was more likely to be unilateral than bilateral (Abdel-Aziz and Foda, 2004). Enameloma was less common than other shape-related dental anomalies (0.5%) and more likely to occur in the maxilla than in the mandible (Gridly and Daas, 1984). Cases of gemination and/or fusion of the upper incisors with supernumerary teeth (Hashim, 2004) or without them (Lotfy, 2014) have been reported.

Table 1. Mean time in months for the emergence of primary teeth in Egyptian children

		Boys					Girls				
		A	B	C	D	E	A	B	C	D	E
El-Hadarary and El-Nesr, 1976	Maxilla	9	10.7	18.4	13.5	24	9.5	11.5	19.5	14.2	25.5
	Mandible	7.8	11.7	18.6	13.5	24	8.5	12.3	19.4	14.3	25.5
Karam, 1987	Maxilla	10	12.8	20	16.5	28	11	12.8	19.5	16.5	27
	Mandible	8.8	14	21.3	16.8	27	9	14	20.3	16.8	26
El-Beheri, 1987	Maxilla	15.4	16.4	22.5	18.4	29.8	13.83	16.98	23.48	19.6	30.04
	Mandible	11.13	18.12	22.79	19.32	29.59	11.46	17.88	25.25	20.67	29.75
El-Batran, 2002	Maxilla	9	11.8	19.6	17.2	26.1	9.4	12.1	19.9	15.7	26.3
	Mandible	5.8	13.1	19.9	17.6	24.2	5.8	13.1	19.2	17.6	24.1
Soliman et al., 2011	Maxilla	9.8	12	19	17.1	25.4	9.9	13.2	19.8	17	28.9
	Mandible	8	13	20.3	17	25.4	7.9	13.2	19.6	16.7	28.1

Table 2. Mean time in years for the emergence of permanent teeth in Egyptian children

		Boys							Girls						
		1	2	3	4	5	6	7	1	2	3	4	5	6	7
Mahdly, 1990	Maxilla	7	8	11.5	10	11.2	6.3	11.9	6.6	7.9	10.6	9.6	10.3	6.6	11.8
	Mandible	6.2	7.2	10.6	10.8	11.5	5.8	12	6.5	6.8	10.1	10.1	10.9	5.8	11.3
Abde El-Hakam, 2015	Maxilla	9.16	9.78	10.9	10.34	10.66	8.64	11.21	10.13	9.58	12	11.04	10.71	6.23	11.29
	Mandible	8.71	9.28	10.9	10.65	10.63	7.12	10.83	8.74	9.22	10.3	10.51	10.92	7.2	11.1

Table 3: Studies reporting on the prevalence of fluorosis in Egypt

Author	Place	Age	Prevalence				Associated factors
			Mild/very mild/ questionable	Moderate	Severe	Overall	
Wasfy, 1973	Alexandria	6-7 11-12	55% 43%	11.6% 17.6%	10.4% 39.4%	77% 100%	
Aboulazm, 2005	Alexandria	12-13	41.5	-	-	85.7	Higher in rural > urban, in maxillary > mandibular, premolars > others. Associated with the amount of toothpaste on the brush
Ramadan, 2010	Mansoura	12-15	23	-	-	-	Associated with tooth brushing with fluoride containing toothpaste, the fluoride content of water, fish intake, and chicken soup intake
Khalifa, 2015	Dakahlia	12, 15 & 35-44	87.8	6.8		94.6	No difference by age or tooth brushing, using F toothpaste, fish eating, using commercial soups, but significantly associated with tea drinking

Table 4. Studies about enamel defects conducted in Egyptian populations

Author	Place	Age	Prevalence	Associated factors
Temtamy, 2006	-	Patients with 3 M syndrome; 11, 12 & 13 years old	-	Hypoplastic premaxilla, thick patulous lips, high-arched palate, median fissured tongue, malocclusion, delayed teeth eruption, enamel hypocalcification
Salem, 2008	Cairo	9-12	Enamel defects: 56%	End stage renal disease on hemodialysis
Salama, 2009	Damietta	12, 15 35-44 65-74	Developmental enamel defects: 11.2% 6.4% 3.8%	-
Hawas, 2012	Cairo	6-14	Enamel hypoplasia: 3.3%	-
El-hodhod, 2012	-	Case (with developmental enamel defects) and healthy control: 4-12 years	-	Celiac disease in children with Developmental enamel defects: 17.86% versus 0.97% in patients with no developmental enamel defects
Lotfy, 2014	Cairo	6-14	Enamel hypoplasia: 3.3% Aplasia of the second premolar: 17.86% Aplasia of the upper lateral incisor: 0.7% Peg-shaped lateral incisor: 0.8% Gemination: 0.4%; Fusion: 0.1% Ectopic eruption of the permanent molars: 0.2%	

Table 5. Studies reporting on black stains in the teeth of Egyptian children

Author	Place	Age	Factors associated with black stains
Ahmed, 2014	Alexandria	4-8 years	Prevalence higher in 6-8-year-old children than in younger children, who were 4 to 6 years old, higher in mixed dentition than in primary dentition, and higher in children with upper respiratory tract than in children with lower respiratory tract diseases
Negm, 2015	Alexandria	3-5.5 years	Actinomyces in 23.8% of children with stain versus none in stain-free children
Sharaf, 2017	Ain Shams	-	Lower levels of phosphorus in saliva. Increased intake of dairy products. Administration of iron supplements during pregnancy and/or lactation

Anomalies of Size

Intellectual disabilities due to chromosomal and single-gene defects were found to be associated with micro and macrodontia in Egypt (Ramzy et al., 2003). Microdontia was also associated with Turner syndrome: 60% in patients with Turner syndrome compared with 30% in healthy controls (Ramzy, 1983).

Anomalies of Number and Position

Hypodontia: Hypodontia was observed in ancient mummies (Klatsky, 1956), with the most frequently missing tooth being the third molar; missing third molars ranged from one to four per mummy irrespective of the size of the jaw (Leek, 1972). Impacted third molars and maxillary canines, as well as retained primary teeth, were also reported in ancient mummies (Leek, 1972; Melcher et al., 1997; Forshaw, 2009); the prevalence of missing third molars ranged from 7% (Ruffer, 1920) to 12% (Greene, 1972). Supernumerary teeth included the upper central incisors (Ruffer, 1920) and the fourth molars (Ruffer, 1920). The prevalence of hypodontia, exclusive of the third molar, is 2.4% (Montasser, 2012). Table 6 reports on publications on dental anomalies affecting tooth numbers in Egyptians.

Hypodontia associated with genetic anomalies has also been reported. Six family members with WNT10A mutation were reported to have hypodontia (Abdalla et al., 2014). An earlier study reported missing maxillary lateral incisors in one of seven patients with Kabuki syndrome (Abdel-Salam et al., 2011). Missing teeth were reported in association with Ellis-van Creveld syndrome in the mandibular anterior region in the primary dentition (Shawky et al., 2010) and in the mandibular and maxillary anterior region in the permanent dentition (Mostafa el al., 2005). Oligodontia was reported in two Egyptian boys, 7 and 9 years old, who had EDA gene mutation; the two boys had missing teeth in the primary and permanent dentitions (Gaczkowska et al., 2016).

Supernumerary teeth: The prevalence of supernumerary teeth among 6-12-year-old children in the Delta area was 0.68% (Raghib, 1980). A higher prevalence of 1.8% was reported in a more recent study conducted in Cairo among 6-14-year-old children (Lotfy, 2014).

Impaction: Table 7 shows studies assessing the prevalence of anomalies of position. The prevalence of tooth impaction ranged from 4.7% (Morshed, 1969) to 67% (Khalil et al., 1984). The most frequently impacted tooth was the mandibular third molar (52%-67%), followed by the maxillary third molar (7.6%-40.8%) and the maxillary canine (3.9%-11.5%) (El-Sharkawy, 1983; Khalil et al., 1984), with one case report describing the impaction of a fourth molar (El-Naggar and Raghib, 2016). Impaction of unerupted teeth was more likely to occur in the maxilla than in the mandible (Morshed, 1969).

Most of the impacted mandibular third molars were vertical (47%) or horizontal (44.5%), with mesioangular impaction presenting with lower frequency (27%) (Abdel All, 1980). Maxillary canine impaction was more common in females than in males, with a ratio of 3:1 (El-Aziz and Foda, 2001), and presented either unilaterally or bilaterally (Abdel-Salam et al., 2012). Unilateral impaction of the maxillary canine was associated with anomalies in the shape of the lateral incisor (Kamel, 2009). Impaction of supernumerary teeth was observed in the maxilla and mandible (Al-Omar, 2017).

Diastema: The prevalence of median diastema in the maxillary arch ranged from 3.1% to 42.8% in 8-30-year-old Egyptians, with a higher prevalence among females. It was associated with peg-shaped lateral incisors and congenitally missing lateral incisors and supernumerary teeth (El Batouti, 1982; Sabaa, 2004).

Table 6. Dental findings reported in some syndromes among Egyptian children

Author	Syndrome	Age	Dental findings
Mostafa et al., 2005	Ellis-van Creveld syndrome	8, 11, 13, 14, 15, 37 years	Congenitally missing lower and/or upper permanent incisors
Shawky et al., 2010	Ellis-van Creveld syndrome	2.5 years	Congenitally missing teeth in the mandibular anterior region
Abdel-Salam et al., 2011	Kabuki syndrome	1, 2, 3, 4, 6, 9 years	Missing upper lateral incisors in 14.3%

Table 7. Publications on the prevalence and position of dental anomalies in Egyptians

Author	Age	Condition	Prevalence
Abdel All, 1980	-	Impaction	Vertical: 47% Mesioangular: 27% Horizontal: 44.5% Distoangular: 1.5%
El Batouti, 1982	8-14 years	Maxillary median diastema	42.8%
El-Sharkawy, 1983	20-31 years	Impaction	Overall: 48% Mandibular 3rd molars: 51.5% Maxillary 3rd molar: 40.8% Maxillary canine: 3.9%
Khalil, 1984		Impaction	Mandibular 3rd molar: 67% Maxillary canines: 11.5% Maxillary 3rd molar: 7.6% Maxillary central incisors: 3.4%
El-Aziz and Foda, 2001	11.5-21 years	Impaction	Maxillary canine: 3.84%
Sabaa, 2004	16-30 years	Maxillary median diastema	Overall: 3.1%, divided into: Genetic: 24.1% Congenitally missing maxillary lateral incisors: 19.6% Congenitally small teeth: 14.5%

Gaps and Recommendation

A surveillance system to periodically and systematically collect data about developmental dental anomalies in Egypt is needed. Such a system would help address gaps about the prevalence of conditions such as amelogenesis imperfecta and other dental anomalies (Ayers et al., 2004; Poulson et al., 2008). Data on the prevalence of developmental dental hard-tissue anomalies would provide evidence for decision-making on provision of care to these patients. There are also no data on the prevalence of fluorosis in primary teeth and factors increasing its risk in both dentitions. Finally, dental education and training programmes should emphasize the importance of using standardized terms and methods in the diagnosis and reporting of dental anomalies to facilitate the comparison of data, which would help in the management of decision-making.

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INDIA

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Background Information of India

India is the world's largest democracy, with a population of over 1,357,779,035 people. According to the United Nations' estimate (UN DESA report), India is expected to become the largest country in population size, surpassing China, by 2022. The people speak 325 languages and 1,652 dialects. India is a union of 29 states and seven union territories. The Indian population is equivalent to 17.74% of the total world population. Figure 1 illustrates the six territories that divide India into various zones socially and culturally.

India is one of the 25 fluorosis endemic countries of the world. Fifteen states in India are endemic for fluorosis, with fluoride levels in drinking water greater than 1.5 mg/l. An estimated 62 million people in India have dental, skeletal and non-skeletal fluorosis, of which six million are children below the age of 14 years (Arlappa et al., 2013). There is a widespread natural occurrence of arsenic and fluoride in the groundwater. In 2008-2009, the Ministry of Health and Family Welfare Government of India launched the National Program on Prevention and Control of Fluorosis in endemic areas.

While an estimated 87.56% of Indians have access to basic drinking water, many remain in a precarious situation because of climate change (WHO/UNICEF, 2017; UNICEF India World Water Day report, 2018).

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Figure 1: The six territories of India

Persons living in fragile situations are four times more likely to lack basic drinking water, which increases their risk of seeking and using contaminated water sources. Over 80% of waste water flows back into the environment without being treated or reused. With 594 million people defecating in the open and 44% of mothers disposing of their children's feces in the open, the risks of microbial contamination of water and children developing water-borne diseases are very high.

Children weakened by frequent diarrhea episodes are vulnerable to malnutrition and opportunistic infections, such as pneumonia. Forty-eight per cent of children in India have some form of malnutrition: of children under the age of 5 years, 39% are stunted, 37% are underweight, 21% are wasted, and 8% are severely acutely malnourished (Spears and Lamba, 2016). The percentage of stunted children under five years old decreased from 48% in 2005-2006 to 39% in 2015-2016 (Spears and Lamba, 2016). The burden of childhood mortality and stunting is a result of 568 million residents lacking access to safe sanitation.

The prevalence of risk factors for congenital defects in India is very high. These factors include universality of marriage, high fertility, a large number of unplanned pregnancies, poor coverage of antenatal care, poor maternal nutritional status, a high consanguineous marriage rate, and a high carrier rate for hemoglobinopathies. Annually, India has the highest number of infants born with birth defects; this is attributed to its large number of births per year – almost 27 million (Christianson, Howson and Modell, 2006).

The prevalence of specific dental conditions, such as developmental defects, varies widely among various different parts of the country. The significance of dental developmental defects is veiled by the continuing high prevalence of infectious diseases and malnutrition. Moreover, data analysis and reporting of significant oral health problems are limited by inadequate diagnostic capability at the community level, unreliable health records and statistics, and poor documentation of most dental defects. Information on the prevalence of dental lesions at the community level is also limited because differing study designs make it challenging to pool data.

Timing and Sequence of Emergence of Primary Dentition

Verma et al. (2017), in a cross-sectional study on the chronology of tooth emergence in Indian children, found significant associations between the timing of tooth emergence and birth weight, feeding habits, socioeconomic status, and body mass index. Also, some gender differences were identified in the timing of emergence of some teeth, as illustrated in Table 1. The emergence of primary dentition was completed by 30 months of age in most children. When the timing of primary teeth emergence in Indian children was compared with that of other populations, the authors concluded that Indian children emerged their primary teeth later than children from other populations, and later than the standard norm.

Table 1: Timing of emergence of primary mandibular and maxillary teeth in Indian children

Tooth	Emergence age in boys (mean ± SD)	Emergence age in girls (mean ± SD)	Emergence age in both (mean ± SD)	Statistical inference
Mandibular central incisor	336.86 ± 107.23 (11.2 months)	350.56 ± 97.44 (11.7 months)	343.11 ± 102.83 (11.4 months)	t-value = 2.63 p-value = 0.008
Mandibular lateral incisor	457.17 ± 102.89 (15.2 months)	431.35 ± 106.30 (14.3 months)	445.29 ± 104.66 (14.8 months)	t-value = 4.90 p-value = 0.0001
Mandibular canine	694.14 ± 134.86	711.26 ± 129.01	701.46 ± 132.40	t-value = 2.56
	(23.1 months)	(23.7 months)	(23.3 months)	p-value = 0.0104
Mandibular first molar	587.06 ± 131.00	549.66 ± 105.36	570.59 ± 121.30	t-value = 6.15
	(19.5 months)	(18.3 months)	(19.03 months)	p-value = 0.0001
Mandibular second molar	893.68 ± 130.45 (29.8 months)	898.39 ± 131.12 (29.9 months)	895.85 ± 130.57 (29.8 months)	t-value = 0.71 p-value = 0.474

Tooth	Emergence age in boys (mean ± SD)	Emergence age in girls (mean ± SD)	Emergence age in both (mean ± SD)	Statistical inference
Maxillary central incisor	384.86 ± 101.91 (12.8 months)	386.43 ± 84.72 (12.8 months)	385.67 ± 93.02 (12.8 months)	t-value = 0.33 p-value = 0.74
Maxillary lateral incisor	432.93 ± 103.79 (14.4 months)	423.29 ± 92.32 (14.1 months)	428.96 ± 99.130 (14.3 months)	t-value = 1.93 p-value = 0.05
Maxillary canine	681.96 ± 132.53 (22.7 months)	692.06 ± 137.60 (23.1 months)	686.41 ± 134.64 (22.8 months)	t-value = 1.48 p-value = 0.13
Maxillary first molar	571.03 ± 123.62 (19.0 months)	540.95 ± 107.06 (18.0 months)	558.62 ± 117.66 (18.6 months)	t-value = 5.11 p-value = 0.0001
Maxillary second molar	894.89 ± 122.69 (29.8 months)	913.76 ± 129.79 (30.4 months)	902.82 ± 125.85 (30.1 months)	t-value = 2.97 p-value = 0.00

SD: Standard deviation

Tooth emergence and birth weight: Verma et al. (2017) reported that the number of teeth present increased with increasing body weight. When body mass index was compared with age-appropriate teeth presence in children, the percentage of children with age-appropriate teeth was lower for severely underweight children (28.9%) than for normal (42.3%) and overweight children (40.0%).

Tooth emergence and feeding practices: Verma et al. (2017) reported that 41% of breastfed-only children had age-appropriate teeth, whereas only 32.9% of bottle-fed-only children had age-appropriate teeth. The percentage of children with age-appropriate teeth was also greater for those who were breastfed and bottle-fed (37.8%) than for bottle-fed only children.

Tooth emergence sequence reverse polymorphism: There was a tendency for lateral incisors, canines, and first molars to emerge earlier in the maxilla than in the mandible in Mysore, a South Indian population (Rao et al., 2014; Devraj et al., 2017). However, the central incisors and second molars emerged earlier in the mandible. In a child population aged 3 to 36 months, the emergence of the first primary molar prior to the lateral incisor revealed a tendency towards reverse polymorphism. This reverse sequence was reported more often in the mandibular arch than in the maxillary arch. Also, 35% of children had this tendency in the mandibular arch, whereas 9% had it in the maxillary arch in another study of South Indian children (Kariya et al., 2017). Tooth emergence was earlier in boys than in girls, but completion of primary dentition took place at the same time for both sexes.

Timing and Emergence Sequence of Permanent Dentition

Lakshmappa et al. (2011) reported the age of emergence of the permanent dentition in children resident in North India. As Table 2 highlights, the median ages for emergence of the maxillary and mandibular permanent teeth were comparable to the worldwide tooth emergence time. The earliest tooth to erupt was the lower first molar (median age of 5.64 years), followed by the lower central incisor (median age of 6.02 years). The sequences of tooth emergence were:

1ºM – CI – LI – 1ºPM – **C** – 2ºPM – 2ºM (Maxilla)
1ºM – CI – LI – **C** –1ºPM – 2ºPM – 2ºM (Mandible)

Tooth emergence in the maxilla was significantly earlier in girls than in boys, except for the canine, second premolar, and second molar. In the mandible, the central incisor and first molar erupted significantly earlier in boys than in girls. There were no gender differences in the timing of tooth calcification at early stages; however, root formation and apical closure were completed earlier in females. The sequence of tooth eruption for boys was:

1ºM – CI – LI –1ºPM – 2ºPM – **C** – 2ºM (Maxilla)
1ºM – CI – LI –1ºPM – 2ºPM – **C** – 2ºM (Mandible)

The sequence of tooth eruption for girls was:

1ºM – CI – LI –1ºPM – 2ºPM – **C** – 2ºM (Maxilla)
1ºM – CI – LI –1ºPM – **C** – 2ºPM – 2ºM (Mandible)

Sharma et al. (2001) conducted a cross-sectional study of 483 children and observed that the eruption of permanent teeth occurred earlier in females than in males. There was no gender difference in the sequence of tooth emergence. Mandibular teeth, however, emerged earlier than their maxillary counterparts.

Singhal et al. (2017) reported on eruption disturbances in Indian populations. The disturbances included ectopic eruptions and delayed or premature eruption of primary and permanent teeth. The tooth most frequently delayed in eruption was the permanent central incisor whereas in primary dentition the mandibular left central incisor was the tooth that showed delay in eruption most frequently. Males were affected by eruption disturbances more than females. Nayak et al. (2011) reported a prevalence of ectopic eruption of 0.80% among 1.06% eruption disturbances described.

Developmental Anomalies of Dental Hard Tissues

Gupta et al. (2011) reported the prevalence of developmental dental anomalies in a population above 14 years of age in Central India called Madhya Pradesh, and observed that 34.28% of permanent dentition had one anomaly, 2.49% had two anomalies, and 53% had more than two anomalies. Ravindran (2016) reported a 32.0% overall prevalence of developmental defects of enamel in children aged 12 to 15 years resident in 10 urban and 10 rural areas of the Kollam district in South India. The

Table 2: Mean ages of permanent teeth emergence in boys and girls

Tooth	Boys	Girls	*t* value	*P* value
Central incisor (CI)				
Maxillary	7.7 ± 1.2	7.46 ± 1.2	−5.071	0.000*
Mandibular	6.8 ± 0.92	6.9 ± 0.92	−5.687	0.000*
Lateral incisor (LI)				
Maxillary	8.67 ± 1.2	8.54 ± 1.1	−3.703	0.000*
Mandibular	7.9 ± 1.02	7.9 ± 1.07	−5.755	0.000*
Canine (C)				
Maxillary	11.68 ± 1.2	11.2 ± 1.1	−0.488	0.626
Mandibular	11.4 ± 1.3	10.8 ± 1.3	−0.286	0.775
First premolar (IPM)				
Maxillary	10.78 ± 1.3	10.5 ± 1.3	−3.047	0.002*
Mandibular	10.9 ± 1.41	10.6 ± 1.41	−3.463	0.001*
Second premolar (IIPM)				
Maxillary	11.5 ± 1.31	11.21 ± 1.19	−4.585	0.113
Mandibular	11.3 ± 1.32	11.5 ± 1.32	−1.388	0.181
First molar (IM)				
Maxillary	5.4 ± 1.18	5.4 ± 1.07	−5.469	0.000*
Mandibular	5.14 ± 1.24	5.18 ± 1.24	−5.560	0.000*
Second molar (IIM)				
Maxillary	12.64 ± 1.138	12.3 ± 1.02	1.380	0.168
Mandibular	12.2 ± 1.17	11.9 ± 1.17	1.443	0.149

* $P \leq 0.05$ is considered as statistically significant

prevalence was higher for children in the urban area (34.3%) than for children in the rural area (29.6%). Patil et al. (2013) reviewed 4,133 panoramic radiographs and reported that 36.7% of patients had at least one developmental dental anomaly. An earlier study reported that 350 of 20,182 patients screened in an outpatient department had anomalies (Guttal et al., 2010); the prevalence of anomalies was higher in male adults (57.43%) than in female adults (42.57%).

Anomalies of Tooth Structure

There are several studies on the developmental defects of enamel and dentine in India. The prevalence of these anomalies varies among the country's zones. Table 3 highlights the studies on gender differences in the prevalence of developmental defects of enamel and dentine. Table 4 highlights studies that reported differences in the prevalence of enamel and dentine developmental defects by socioeconomic status. Dentinogenesis imperfecta was the rarest anomaly with a prevalence of 0.09%, followed by amelogenesis imperfecta with a prevalence of 0.27% (Gupta et al., 2011).

Basha et al. (2014) reported a 42.19% prevalence of developmental defects of enamel in the primary and permanent dentitions of school children aged 6-13 years. The most prevalent lesion in both the primary and permanent dentition was demarcated opacities, and this lesion was more prevalent in permanent than in primary dentition. Of the demarcated opacities, 17.79% of boys and 12.5% girls were reported with the lesion. The most affected teeth were permanent maxillary central incisors and primary maxillary second molars. Factors associated with an increased risk for developmental defects of enamel were low socioeconomic status, childhood obesity, maternal illness during pregnancy, low birth weight, and systemic illness during a child's first five years of life.

Ravindran (2016) reported a prevalence of demarcated opacities of 28.76%; the tooth most commonly affected was the maxillary right lateral incisor, and the least affected tooth was the maxillary right first premolar. Chauhan et al. (2013) reported a 51.3% prevalence of developmental defects of the enamel in children residing in the hilly areas of Himachal Pradesh in Northern India. Of these, 25.3% had demarcated opacities, 2.9% had enamel hypoplasia and 23.1% had diffused opacities of enamel.

Krishnan et al. (2015) reported a prevalence of molar incisor hypomineralization of 7.3% in children who resided in an endemic fluorosis area, where the fluoride concentration of groundwater was 0.8-14.7 ppm. The prevalence was 8.1% in girls and 6.1% in boys; however, the lesion was more severe in boys. Mittal et al. (2014) reported a prevalence of molar incisor hypomineralization of 6.31% and Parikh et al. (2012) reported a prevalence of 9.2%. A study by Yannam et al. (2016) reported a prevalence of 9.7%, with a higher predilection for molars than incisors, in 8-12-year-old children who resided in Chennai, South India.

The reported prevalence of dental fluorosis in areas with high fluoride concentrations in drinking water ranged from 21.0% (Chaudhary, 2017) to 30.8% (Krishnan et al., 2015) and 70.3% (Reddy et al., 2017).

Table 3: Gender and the prevalence of developmental defects of enamel and dentine

STUDY	AUTHORS	AIM	RESULT
N=1,398 Children aged 2-5 years 735 boys and 633 girls recruited from Jodhpur Dental College	Deolia et al., 2015	Prevalence of dental anomalies of primary dentition among Indian children in Jodhpur, Rajasthan, India	Prevalence: 4% Girls: 5.8% Boys: 2.7%
N=20,182 Adult patients recruited from the outpatient department of SDM Dental College Dharwad, Karnataka	Guttal et al., 2010	Frequency of developmental dental anomalies in the Indian population	Prevalence: 35% Males: 57.43% Females: 42.57%
N=600 Children recruited from schools in the Karad District of Maharashtra	Kathariya et al., 2013	Prevalence of dental anomalies among school children in India	Prevalence: 39.2% *Hypodontia* Males: 1.8% Females: 3.0% *Microdontia* Males: 1% Females: 3.3% *Talon cusp* Males: 4.3% Females: 2.0%

STUDY	AUTHORS	AIM	RESULT
N=4,750 Patients aged 8-72 years in Jodhpur, India	Patil and Maheshwari, 2014	Prevalence of impacted and supernumerary teeth in the North Indian population	Prevalence: 16.8% Impacted canines were more common in females. Supernumerary and impacted premolars and molars were more common in males.
N=1,080 Patients aged 18-62 years from Odisha, India	Goutham, 2017	Prevalence of dental anomalies in the Odisha Population: A Panoramic Radiographic Study	Prevalence: 35.27% Dilacerations: 46.71% Peg laterals: 20.99% Other anomalies were higher in males
N=4,341 Mothers interviewed at Chennai, Tamil Nadu, India	Yen and Kuppuswami, 2017	Incidence of natal teeth in newborns in the Government Medical College and Hospital, Chengalpattu	Number of children with natal teeth: .09%
N=2,757 Children aged 4-6 years recruited from schools in Burdwan, West Bengal	Mukhopadhyay and Mitra, 2014	Anomalies in primary dentition	Number with anomalies: Girls: (55.3%) Boys: (44.7%)
N=1,123 Patients, older than 14 years from Indore, Madhya Pradesh	Gupta et al., 2011	Prevalence and distribution of some developmental dental anomalies	Prevalence: 34.28% Males: 34.44% Females: 34.06%

Table 4: Socioeconomic status and the prevalence of developmental defects of enamel and dentine

STUDY	AUTHOR	AIM	RESULT
N=1,550 School children aged 6 and 13 years in Devangere city, India	Basha et al., 2014	Prevalence of developmental defects of enamel and dentine and associated factors in primary and permanent dentition	Prevalence: 42.19% Low socioeconomic status: 52.65%
N=2,500 Children recruited from 10 urban and 10 rural schools in Kollam district, Kerala, India	Ravindran and Saji, 2016	Prevalence of developmental defects of enamel in children aged 12-15 years in Kollam District	Prevalence: 32% Urban schools: 34.3% Rural schools: 29.6%

A 100% prevalence was reported in the endemic fluorosis area of Nalgonda by Sudhir (2009).

Anomalies of Tooth Number

Patil et al. (2013) conducted a retrospective study of 4,133 panoramic radiographs of patients aged 13 to 38 years, and assessed the prevalence of congenitally missing teeth, impactions, ectopic eruption, supernumerary teeth, odontoma, dilacerations, taurodontism, dens in dente, gemination, and fusion. The most prevalent lesion was hypodontia, with a prevalence of 16.3%, followed by impacted teeth (15.5%), and supernumerary teeth (1.2%). Guttal et al. (2010) reported the most prevalent types of supernumerary teeth were paramolars, followed by mesiodens and supernumerary teeth in the anterior region.

Rajeshwari et al. (2015) also reported that the most prevalent anomaly of tooth number in the Karnataka population in South India was hypodontia, with a prevalence of 4.19%. This prevalence was higher than the 2.4% prevalence of hyperdontia reported by Kayal et al. (2011). A lower prevalence of 2.9% for hypodontia was also reported by the same author in a general Indian population.

Shilpa et al. (2018) conducted a cross-sectional study of 4,180 South Indian children and reported a prevalence of 0.88% for hypodontia, and a 0.21% prevalence of hyperdontia for the primary teeth. The prevalence was higher in boys than in girls (2.5% vs. 1.9%).

Anegundi et al. (2014) reported a prevalence of 1.24% for supernumerary teeth from their 12-year retrospective study of supernumerary teeth in non-syndromic South Indian pediatric patients who visited outpatient clinics in a dental hospital. Children up to 14 years of age were included in the study, and their clinical and radiographic (occlusal, periapical, and panoramic radiographs) data were reviewed. A slight male predilection of 1.55:1 was noted and conical mesiodens (82.28%) was the commonest anomaly reported followed by supplemental tooth (8.35%) and tuberculate mesiodens (0.51%). The supernumerary teeth had a predilection for the pre-maxilla: 92.53% of supernumerary teeth were located in the pre-maxilla.

Yen et al. (2017) reported on the prevalence of natal teeth in newborn infants at a university hospital over a seven-month period. Of the 4,341 children born during the study period, only four were born with natal teeth. Mandibular incisors were the most commonly occurring natal teeth. All four cases occurred in females; they presented with edema of the gingival tissue overlying an unerupted, but palpable, tooth. Three neonates had two natal teeth, and one had six teeth.

Basavanthappa et al. (2011) reviewed the case notes of neonates who visited the Department of Pedodontics in Southern India between 2003 and 2006. Seventeen teeth (six natal, 11 neonatal) were reported in 15 patients. No significant gender predilection (eight males, seven females) was found. Sixteen natal/neonatal teeth were in the mandibular incisor area (ten on the right side and six on the left), and one tooth was in the maxillary incisor area. Natal/neonatal teeth were present unilaterally in 13 patients and bilaterally in two patients. Three cases were associated with enamel hypoplasia, three with Riga-Fede disease, one with gingival hyperplasia, and one with cleft lip and palate. Radiographic examination confirmed these teeth to be supernumerary, and all were hypermobile. Extraction was performed in all of the cases. Of the extracted teeth, eleven exhibited only rudimentary roots and six had no roots.

Anomalies of Tooth Size

Microdontia: The most common anomaly of tooth size was microdontia, with a prevalence of 2.58% in the school child population of western India Maharashtra (Kathariya et al., 2013). The majority of the microdonts were peg-shaped laterals. There was a female preponderance for the lesion: the prevalence in females was 3.3%, whereas the prevalence in males was 1.0%. Gupta et al. (2011) also observed a female preponderance: the prevalence in females was 3.2% and in males 1.93%.

Macrodontia: There are few studies on the prevalence of macrodontia. Gupta et al. (2011) reported a prevalence of 3.8%, while Singhal et al. (2017) did not identify any macrodontia in their study.

Anomalies of Tooth Shape

Double teeth: Guttal et al. (2010) reported a prevalence of 4.85% for double teeth in the Indian population, and double teeth constituted 0.28% of the dental anomalies. In a cross-sectional study of 600 children, Kathariya et al. (2013) reported a prevalence of 1.8% in males and 1.2% in females. Gupta et al. (2011) reported a lower prevalence of 0.35% in males and 0.18% in females.

Talon cusp: Dash et al. (2004) reported a prevalence of less than 1% to 8% in their documentation of talon-cusp dental anomalies in various Indian populations. Gupta et al. (2011) reported a prevalence of 1.23% in males and 0.72% in females, with an overall prevalence of 0.97% (0.18% unilateral and 0.54% bilateral). Anitha et al. (2018) reported the lowest prevalence, of 0.05%, which was like the 0.07% prevalence reported by Mukhupadhyay and Mitra (2014) in their study of 2,757 children aged 4-6 years.

Taurodontism: Nagaveni et al. (2012) found eight (4.08%) taurodont primary mandibular first molars in 274 children. Bilateral taurodontism constituted 38% of the taurodontism cases, and all bilateral cases had a symmetrical distribution. The prevalence did not differ significantly between the right and left sides, and no gender predilection was observed. Taurodontism was relatively uncommon in the North Indian population (Patil et al., 2013): 17 (0.4%) of 4,143 persons screened in a regular outpatient department of a hospital had taurodontism. The prevalence was 0.21% for males and 0.19% for females. Taurodonts were significantly more common in the maxilla (65.6%) than in the mandible (34.4%). The maxillary second molar (34.4%) was the most commonly involved tooth. Hypotaurodonts were most common (75%), and there was no significant gender difference in its prevalence.

Anomalies of Tooth Location

Gupta et al. (2011) reported a prevalence of 7.93% for ectopic teeth. Gautham et al. (2017) reported a prevalence of 0.24% for rotated teeth and 3.43% for transposed teeth.

Gaps and Recommendations

We have limited the referencing of publications to the years after 2000 so as to enable us to provide up-to-date information. We are however aware that there are a significant number of publications on the subject matter in India. We however noticed gaps in the collection and reporting of data from India. Geographic differences in the reported prevalence of developmental dental anomalies may reflect ethnic variability. However, it is difficult to be certain because of the variability in data collection methods, including how lesions are defined. Synthesis of existing data from India is therefore, challenging. A lot more can be done with data from the regions in India if a global data collection standardized tool for developmental dental anomalies is developed.

Also, the poor training of professionals who collect patients' medical records increases the risk for suboptimal diagnosis and documentation of lesions. Retrospective studies are, therefore, fraught with multiple deficiencies. In the future, the development of a universal diagnostic index for many types of dental lesions will enhance training and data collection and increase the reliability and validity of data.

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INDONESIA

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Background Information on Indonesia

Indonesia is the largest archipelagic country in the world, with an estimated 17,504 islands. It is the world's fourth most populous country, and bridges two continents – Asia and Australia – as illustrated in Figure 1. The country consists of 34 provinces situated between two oceans – the Pacific and Indian oceans. Sumatra, Java Madura, Kalimantan, Sulawesi and Papua are the largest islands; they share land borders with Papua New Guinea, East Timor and Malaysia (World Health Organization, 2017a).

Figure 1. Map of Indonesia (from http://indonesiamap.facts.co/)

Indonesia is one of the countries in Southeast Asia that has achieved remarkable economic success over the past decade, and it is regarded as one of the best-performing countries. It is currently emerging from its political and economic crisis and has undergone tremendous structural and political reforms. Its strong economic growth is leading the country towards middle-income status (World Bank, 2018).

Over recent decades, the Indonesian government has invested heavily in public health, resulting in the significant improvement in health status of the general population. Life expectancy at birth has increased from 66.3 years in 2000 to 69.1 years in 2015. Life expectancy has also increased from 59.4 years in 2000 to 62.1 years in 2015 (World Health Organization, 2017b). Health development programs are targeted at various segments of the population, stratified by age. A total of 33,733,297 children under six years of age, constituting 13.38% of the total population of 252,120,458, are priority targets for health interventions. The other priority targets are school-aged children, pregnant women, and the elderly (Ministry of Health, 2016a).

The Indonesian health program aims to develop national health, encourage people to live healthily, encourage self-reliance, increase health care quality, and improve the health of individuals, families and communities (Ministry of Health, 2016b). However, Indonesia still must manage the persistent problems of maternal and child health associated with malnutrition and a high burden of communicable diseases, particularly in rural and remote areas. The prevalence of non-communicable disease and associated risk factors is increasing in urban and more wealthy areas (World Health Organization, 2017a).

Timing and sequence of emergence of primary and permanent dentitions

Information on teeth eruption time is essential to dentists. In general, humans have 20 primary teeth and 32 permanent teeth. The eruption time of a tooth can vary among people; thus, a normal standard of dental growth is needed for the physiological assessment of children. Unfortunately, there is no standard regarding the time of tooth eruption explicitly intended for Indonesian children; the standard used for eruption is one that has been commonly used internationally as shown below.

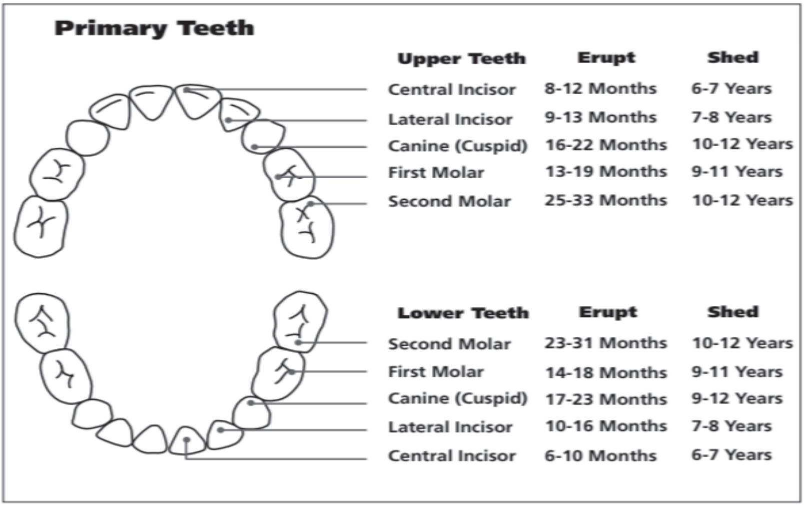

Figure 2. Primary teeth eruption sequence (from: https://www.ada.org/)

However, apart from the absence of an Indonesian standard, there is an interesting study about permanent tooth eruption in Javanese children. The results showed there was a difference in the order of permanent tooth eruptions between boys and girls, and the boys are more advanced in their tooth eruption than girls. On average, the beginning of tooth growth is at the median age of 6.70 years and finishes at the median age of 11.86 years (Indriati, 2001).

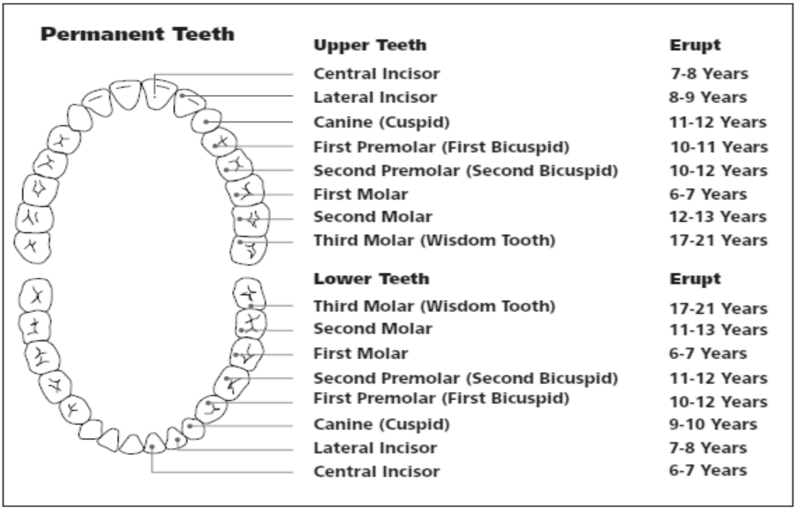

Figure 3. Permanent teeth eruption sequence (from: https://www.ada.org/)

Risk Factors for Anomalies of Tooth Emergence

Nutrition: Nutrition status is a risk factor for tooth emergence. Recent studies by Alhamda (2012) and Zakiyah, Prijatmoko and Novita (2017) demonstrated a significant association between nutritional status and the emergence of the permanent first molar. Tooth emergence was delayed in underweight children compared with that of children who are normal weight or obese. The first permanent molar, however, emerged earlier in children with obesity than children with normal weight for age, and those who were underweight. Alhamda (2012) demonstrated that the first molars had not emerged in more than 20% of underweight students in comparison with 6.6% of students with a normal body mass index. Nutrition also affected the timing of emergence of the permanent mandibular central incisors. Rahmawati, Retriasih, and Medawati (2014) showed that a larger proportion of children with poor nutritional status had unerupted permanent central mandibular incisors than children with good nutritional status. Also, Lantu, Kawengian and Wowor (2015) found that children who were obese or had good nutritional status had more emerged permanent teeth than children with poor nutritional status for the same age.

Low birth weight: Soewondo and Effendi (2014) showed that children born prematurely with low birth weight had delayed primary teeth eruption compared with that in children born full term.

Systemic diseases: Tooth emergence in children with thalassemia was slower than for normal children (Hayati, 1999). Also associated with thalassemia are the premature loss of the primary tooth, a retained primary tooth and enamel hypoplasia. A peg-shaped upper lateral incisor tooth is present in children with HbE thalassemia, as in those with thalassemia β major (Hayati, 1999).

Developmental Dental Hard-tissue Anomalies

A few epidemiological surveys have been conducted in Indonesia to determine the prevalence of various types of dental anomalies. Most studies have been limited to populations of school children resident in a few localities. A few of these studies are published in journals. Below are reports of studies, including those not published but accessible in the repository of several universities in Indonesia.

Agenesis: Rasyid and Asmawati (2013) conducted a study in Makassar city (South Sulawesi), where they screened 1,910 children of 12-15 years old. The prevalence of agenesis was 0.1%, and agenesis was found only in girls and affected the anterior mandible.

Fluorosis: The prevalence of fluorosis in some areas of Indonesia is high and has become a serious health problem. Indonesia is on the world's volcanic belt and thus has the potential for high fluoride concentrations in its waters. Studies conducted in the Asembagus Situbondo area, in East Java, in 2002 showed that 96% of study participants had clinical signs of dental fluorosis. The average community fluoride index score was 1.7, with fluoride levels of 0.5 mg/l to 0.81 mg/l in the drinking water (Budipramana et al., 2002). Munadziroh (1997) conducted a study in other parts of Indonesia – Kuala Tanjung village, North Sumatra, which is near the aluminium smelters; the village had a fluoride concentration in drinking water of 0·26 to 0·413 mg/l, and the prevalence of fluorosis was 77·32%, with a community fluoride index score of 1 to 5. In North Sulawesi, Mariati (2010) demonstrated a significant positive correlation between the fluorine content of drinking water and the severity of dental fluorosis: the higher the fluoride content in drinking water the more severe is the dental fluorosis. Also, the study found that the mean value of fluorine content in drinking water was 1.32 mg/l, with most dental fluorosis lesions being very mild to mild. Results of studies on fluorosis in

Indonesia suggest that the geomorphology is a factor in the prevalence and severity of the lesion.

Table 1. Research on dental anomalies conducted in Indonesia

Author (year)	Study	Subjects	Outcome
Rasyid and Asmawati, 2013	Makassar, South Sulawesi	Children 12-15 years old	Agenesis prevalence 0.1%. Prevalence higher in females. Largest proportion found in the anterior mandibula
Alhamda, 2012	Lintau Buo District, Tanah Datar regency	School students aged 6-7 years	Significant association between nutritional status and the eruption of permanent first molars ($p < 0.001$; $r = 0.389$)
Rahmawati, Retriasih and Medawati, 2014	Yogyakarta Special Region, Java	Students 6-7 years old.	Significant relationship between nutrition status and emergence of permanent mandibular central incisor teeth ($P < 0.05$)
Soewondo and Effendi, 2014	Bandung, West Java	low birth-weight, prematurely born children aged 4-30 months.	Teeth emergence in prematurely born children with LBW significantly delayed ($p < 0.01$).
Lantu, Kawengian and Wowor, 2015	Manado, North Sulawesi	Children 6-12 years old	Significant relationship between malnutrition and delayed permanent tooth eruption

Table 1. Research on dental anomalies conducted in Indonesia

Zakiyah, Prijatmoko and Novita, 2017	Jember District, South Java	1st grade students	Significant difference between the date of emergence of the first permanent molar by nutritional status among 1st grade students in Jember district area ($p < 0.001$)
Munadziroh, 1997	Kuala Tanjung Village, Asahan District and surrounding area, North Sumatra	Children 12-15 years	Drinking water with a fluoride content of >0.4 mg/l is associated with fluorosis
Budipramana, Hapsoro, Irmawati and Kuntari, 2002	Asembagus Situbondo East Java	Children 6-12 years	Significant relationship between fluoride water content and the Community Fluorosis Index
Mariati, 2010	Ratatotok District, South East Minahasa North Sulawesi Province	Junior and Senior High School students with fluorosis	Fluoride content in drinking water sources is associated with dental fluorosis. The higher the fluoride content in drinking water the more severe is the dental fluorosis
Hayati, 1999	Jakarta Special Region, Java	Children 6-18 years old with thalassemia	Tooth emergence of children with thalassemia is slower than in normal children of the same age group

Gaps and Recommendations

Law No. 36 (2009) states that oral health services are aimed at maintaining and improving public health status through integrated central, local and community governance in a sustainable manner. Ministry of Health Decree No. 89 (2015) states that oral health services are provided at each individual growth stage through a life-cycle approach. In accordance with this law, oral health programs in Indonesia are integrated with other general health plans and health-promotion programs. One of the important general health programs related to oral health is nutrition. To accelerate improvement of nutrition, the government issued Presidential Regulation number 42 (2013), titled the National Movement for the Acceleration of Nutrition Improvement. The program focuses on the first 1,000 days of the life of each child (Bappenas, 2013).

The nutrition program was developed to meet the global target for the year 2025, primarily for women and children. It was designed to reduce the proportion of low-birth-weight infants, stunting and obesity. Despite the policies, a large proportion of children in Indonesia are still malnourished. Dentists must do more in promoting nutrition programs in families. The child’s nutritional status not only affects caries and periodontal disease status but also affects the growth and development of children, with effects on the risk for development of dental anomalies and oral health (Palmer, 2007).

Dental fluorosis is a prominent, complex oral health problem in Indonesia. Little work is being conducted on the prevention of fluorosis, and there is still no mapping of endemic fluorosis areas. Naturalization of drinking water sources high in fluoride content is also not a health- policy issue. The country must address the prevention of fluorosis for children living in endemic areas. Despite the problem of fluorosis, the country promotes the use of fluoridated toothpaste twice a day by children as a strategy for caries prevention. Toothpaste containing fluoride is massively sold all over Indonesia and is promoted as the best way to avoid caries (Ministry of Health, 2012).

Studies on the etiology of dental anomalies in Indonesia are still needed. Linking the prevalence of anomalous dental conditions to general health is one way to demonstrate the importance of integrated health. Studies on genetic and other environmental risk factors for delayed tooth eruption in Indonesia are needed. Dental health personnel must also be engaged in monitoring the development of children so prompt preventive or curative interventions can be initiated.

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ISLAMIC REPUBLIC OF IRAN

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Background on Iran

Iran is the second-largest country in the Middle East. It is a diverse country, consisting of many ethnic and linguistic groups. The country is divided into 31 provinces (Figure 1). Tehran, with a population of around 8.8 million (2016 census), is the capital and the largest city of Iran. The country's population has increased by 29.1% in the past 25 years, reaching 79.5 million in 2015. It is estimated that 28.2% of the population live in rural settings, 17.5% are between 15 and 24 years of age, and life expectancy at birth is 74 years. The literacy rate for youths (15-24 years of age) is 98.0%; for all adults, the rate is 84.3%, and for adult females, it is 79.2% (World Health Organization, 2015).

Despite a nutritional transition, with an increase in the rate of over nutrition in Iran, stunting is still prevalent among children under 5 years of age. In Iranian children under 5 years of age the prevalence of underweight, wasting, severe wasting and stunting was 4.1%, 4.0%, 1.4% and 6.8% respectively. Iodine deficiency affects 5.6% of the population. The prevalence of exclusive breastfeeding among children under 6 months of age was 23.0%, and low birth weight was 7.7% (World Health Organization, 2015).

The government is committed to developing and implementing nutrition and food policies to simultaneously combat increased rates of obesity and

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micronutrient deficiencies. Examples of the government's efforts include mandatory flour fortification with iron and folic acid, milk fortification with vitamin D, weekly iron supplementation for adolescent schoolgirls, and daily micronutrient supplementation for pregnant women and children under 2 years of age through primary health care clinics (World Health Organization, 2015).

Figure 1. Map of Iran's 31 provinces.

The main studies on eruption time in permanent teeth in Iran were conducted in Tehran City. Other study sites were Shiraz City, a main city in the South of Iran; Tabriz City, a cold mountainous major city in the north of Iran, with the Turk ethnic group; and Kerman, a dry, desert city in the center of Iran.

A systematic review on drinking-water fluoride concentrations in Iran from 1990 to 2015 showed that the concentrations were higher in the southern parts of Iran and in some areas of Azerbaijan-e-Gharbi Province in the northwest and were lower in the rest of the northwest and central parts. Iran is one of 20 countries that have fluorotic areas (Azami-Aghdash et al., 2013). Also, Azami-Aghdash et al. (2013) detected that only three provinces in Iran had water fluoride concentrations with the required standard range recommended by the World Health Organization; the average fluoride concentration was estimated to be 0.43 ± 0.17 ppm in Iran.

Major studies on the timing of eruption of the primary dentition were conducted in Tehran; in Rasht, in the north of Iran; in Tabriz, in the northwest; and in Hamedan, in the northwest. Studies conducted on tooth eruption profiles of children in Iran, using appropriate methodology, are rare.

Multiple studies have been conducted on developmental dental hard-tissue anomalies – anomalies of shape, number, structure and location – in Iran. These studies have investigated the prevalence of developmental dental hard-tissue anomalies among communities and ethnic groups. Most of the studies are based on panoramic radiographs of dental patients; the absence of population-based studies introduced bias into the data collection process.

Eruption Profile of Permanent and Primary Teeth

Permanent Teeth

Age of tooth emergence: Table 1 shows the means, standard deviations, and medians in the emergence time of permanent teeth in boys and girls in Tehran in 2004 and 2018 reported in months (Moslemi, 2004; Amiri, Hessari and Asefi, 2018). Moslemi (2004) reported on the mean time of emergence of all the permanent teeth, the range of variation in the emergence time of each tooth, and the sequence of emergence for boys and girls in Tehran. The sample size for the study was 3,744 school children – 1786 girls and 1958 boys – aged 4-15 years, randomly selected from schools and training centers in the 20 districts covered by the General Department of Education and Training. The study reported that the first teeth to emerge in girls were the mandibular central incisors: the lower right central incisor emerged at a mean age of 78 months (range, 57-86 months) and the lower left central incisor emerged at a mean age of 78 months (range, 53-86 months). The emergence of the lower incisors was followed by emergence of the mandibular first molars, at a mean and median age of 80 months (a range of 56-92 months for the mandibular right first molar, and a range of 57-92 months for the mandibular left first molar).

In girls, the minimum range of variation in emergence time – 29 months – was observed in the mandibular right central incisor, while the maximum range – 72 months – was observed in the second premolars. In boys, the minimum range of variation in emergence time – 35 months – was observed in the mandibular left central incisor, while the maximum ranges of variation – 75 and 74 months – were observed in the mandibular right first premolar and maxillary left canine, respectively. The emergence times of the canines and premolars reported by Amiri et al. (2018) were earlier than those reported by Moslemi in 2004 (Table 1).

Gender differences in emergence time: The emergence time was earlier in girls than in boys (Moslemi, 2004; Elham and Adhamy, 2010). The study of 1,728 5-13-year-olds in Shiraz showed a difference in emergence time between girls and boys, ranging between 1 and 14 months: the lowest difference in the emergence time – one month – was observed for premolars and molars, while the highest difference was observed for lateral incisors – 14 months. Except for the maxillary premolars, the emergence of the permanent teeth occurs significantly earlier in girls than in boys (Banakar, Zarrindast and Sabetahd, 2000). Amiri et al. (2018), however, found a statistically significant gender difference in the emergence times of the maxillary left first premolar only. The emergence pattern was symmetric in both genders. There also was no gender difference in the emergence time of the first molars for children in Tabriz (Poureslami et al., 2015).

Differences in emergence time of maxillary and mandibular teeth: Moslemi (2004) observed that the mandibular teeth have earlier emergence times than the maxillary teeth in both girls and boys in Tehran. Amiri et al. (2018) also observed that for the same population, the canine in the mandible emerged earlier than the corresponding tooth in the maxilla, and the first premolars in the maxilla emerged later than the corresponding teeth in the mandible. These findings are highlighted in Table 1. A study conducted in Kerman also showed that the mandibular teeth have an earlier emergence time than their maxillary counterparts in both girls and boys, except for the first and second premolar (Elham and Adhamy, 2010).

Table 1: Mean and median ages of permanent tooth emergence in children in Tehran, Iran, in 2004 (Moslemi, 2004) and 2018 (Amiri, Hessari and Asefi, 2018).

Maxilla*		11	12	13	14	15	16	17	21	22	23	24	25	26	27
Boys 2004	Mean	97	113	151	138	150	82	157	96	110	158	136	147	82	154
	SD	8	10	12	14	14	9	12	9	9	16	12	12	9	11
	Median	96	110	149	136	148	81	156	95	108	157	133	144	81	152
Boys 2018	Mean	-	-	121	120	122	-	-	-	-	121	121	122	-	-
	SD	-	-	7	7	6	-	-	-	-	7	7	6	-	-
Girls 2004	Mean	93	103	146	133	151	80	151	88	108	146	133	151	81	151
	SD	8	8	14	14	16	8	11	6	11	14	14	16	8	11
	Median	92	102	144	131	149	80	149	86	106	144	131	149	80	149
Girls 2018	Mean	-	-	122	122	124	-	-	-	-	122	123	124	-	-
	SD	-	-	7	7	7	-	-	-	-	7	7	7	-	-

Mandible*		41	42	43	44	45	46	47	31	32	33	34	35	36	37
Boys 2004	Mean	80	101	141	146	154	82	155	82	101	141	140	157	82	149
	SD	7	10	11	16	14	9	13	8	10	11	12	15	9	11
	Median	79	100	139	144	153	81	153	81	100	139	138	156	82	147
Boys 2018	Mean	-	-	-	119	119	119	-	-	-	120	119	118	-	-
	SD	-	-	-	7	7	7	-	-	-	7	7	7	-	-
Girls 2004	Mean	78	94	126	134	152	80	149	78	96	120	132	151	80	144
	SD	6	6	10	13	16	8	13	6	8	8	11	15	8	13
	Median	77	93	125	113	150	80	146	77	95	119	130	148	79	146
Girls 2018	Mean	-	-	-	122	122	123	-	-	-	122	121	122	-	-
	SD	-	-	-	7	7	8	-	-	-	7	8	8	-	-

*The tooth numbering is based on the FDI system. Maxillary central incisor: 11 and 21; Mandibular central incisor: 41 and 51; Maxillary lateral incisor: 12 and 22; Mandibular lateral incisor: 42 and 52; Maxillary canine: 13 and 23; Mandibular canine: 43 and 53; Maxillary first molar: 14 and 24; Mandibular first premolar: 34 and 44; Maxillary second premolar: 15 and 25; Mandibular second premolar: 35 and 45; Maxillary first molar: 16 and 26; Mandibular first molar: 36 and 46; Maxillary second molar: 17 and 27; Mandibular second molar: 37 and 47.

Bilateral differences in emergence time: Elham and Adhamy (2010) found no significant difference in the emergence time between the right and left corresponding teeth for children in Kerman. In Shiraz, however, there were differences in the time of emergence of the lower central incisors in girls (4 months), lower canines in girls (7 months), and upper first molars in boys (8 months), bilaterally (Banakar, Zarrindast and Sabetahd, 2000). Amiri et al. (2018) reported no differences related to the mean age of emergence time of teeth bilaterally except for the second premolars.

Sequence of permanent tooth emergence: Large differences in the sequence of tooth emergence within and between populations have been reported in Iran (Moslemi, 2004). Table 2 shows the sequence of tooth emergence. In Kerman, the sequence of emergence of the mandibular canine and first premolar differed between girls and boys (Elham and Adhamy, 2010). In Shiraz, the emergence of the central incisors, mandibular first molar, canine and mandibular first premolar was simultaneous (Banakar, Zarrindast and Sabetahd, 2000). In Tabriz, the first teeth to emerge were the mandibular first molars, in 65.2% of the population, and the mandibular central incisors, in 34.8% of the population (Poureslami et al., 2015).

Factors affecting variability in the tooth emergence pattern: Ethnicity was an identified factor associated with differences in the timing of tooth emergence. The age of tooth emergence in the maxilla – except for the canine – was a bit later in children in Kerman than in children in Tehran. Similarly, the age of tooth emergence was later for children from Shiraz (Banakar, Zarrindast and Sabetahd, 2000; Moslemi, 2004) and Tabriz (Poureslami et al., 2015) than for children from Tehran. These finding are relevant for dental treatment planning and forensic evaluation, and they should be reviewed at designated intervals (Elham and Adhamy, 2010). Amiri et al. (2018), however, found no ethnic difference in the time of tooth emergence; their study of ethnic groups in Tehran showed that children of various ethnic groups had approximately the same mean age for the corresponding teeth.

Differences in tooth emergence may be linked to socioeconomic status. Some studies showed that when parental education is used as a proxy for socioeconomic and nutritional status, children whose parents have higher levels of education were more likely to have emerged their canine bilaterally compared with the emergence time in children with lower socioeconomic status (Mahmodian, Kowsari and Javadi-nejad, 1998;

Table 2. The order of tooth emergence in the maxilla and mandible			
City/ethnic group	Gender	Maxilla	Mandible
Tehran (Moslemi, 2004)	Girls	First molars, Central incisors, Lateral incisors, First premolars, Canines, Second premolars, Second molars	Central incisors, First molars, Lateral incisors, Canines, First premolars, Second premolars, Second molars
	Boys	First molars, Central incisors, Lateral incisors, First premolars, Second premolars, Canines, Second molars	Central incisors, First molars, Lateral incisors, Canines, First premolars, Second premolars, Second molars
Kerman (Elham and Adhamy, 2010)	Girls	First premolars, Second premolars, Canines	Canines, First premolars, Second premolars
	Boys	First premolars, Second premolars, Canines	First premolars, Canines, Second premolars
Shiraz (Banakar, Zarrindast and Sabetahd, 2000)	Girls	First molars, Central incisors, Lateral incisors, First premolars, Canines, Second premolars	First molars and Central incisors, Lateral incisors, Canines, First premolars, Second premolars
	Boys	First molars, Central incisors, Lateral incisors, First premolars, Second premolars, Canines	First molars and Central incisors, Lateral incisors, Canines, First premolars, Second premolars
Tehran (Amiri, Hessari and Asefi, 2018)	Girls	First premolars, Second premolars, Canines	First premolars, Second premolars, Canines
	Boys	Canines, First premolars, Second premolars	First premolars, Canines, Second premolars

Amiri, Hessari and Asefi, 2018). Also, the emergence of the canines and first and second premolars was later in children whose parents had a higher education level (Amiri, Hessari and Asefi, 2018). Poureslami et al. (2015), however, found no significant correlation between the emergence time of the first permanent teeth and socioeconomic status of children in Tabriz (Poureslami et al., 2015).

Finally, variations in the emergence time of permanent teeth are associated with deviations in the eruption time of primary teeth: the emergence time of the permanent teeth increased with increasing magnitude of the deviations in the emergence time of primary teeth. The emergence time for first primary and permanent teeth had the strongest correlation: a one-month delay or early eruption of the first primary tooth resulted in a 4.21-month delay or early eruption of the first permanent tooth (Poureslami et al., 2015).

Primary Dentition

Age of tooth emergence: In a comprehensive longitudinal study on the emergence time of primary teeth in Tehran, the first teeth to emerge were the mandibular central incisors, at 7.9 ± 2.4 months. The last primary tooth to emerge was the second upper molar, with a mean eruption age of 24.8 ± 3.5 months (Mahmoudian, Ghandharimotlagh and Khoujani, 2005). Table 3 shows the time of emergence of primary teeth in a sample of children in Tehran.

Difference between genders: In Rasht, the emergence of the mandibular central incisor ranged from 5 to 14 months, with a mean emergence age of 9.93 ± 0.11 months for girls and 10.13 ± 0.1 months for boys (Vejdani et al., 2015). The emergence time in this population was later than that of children in Tehran. The time of emergence of the maxillary centrals and the mandibular right central was earlier in boys than in girls in Tehran, though the overall emergence time had no gender differences (Mahmoudian, Ghandharimotlagh and Khoujani, 2005). In Tabriz, (Poureslami et al., 2015) and Rasht (Vejdani et al., 2015), however, the time of emergence of the first primary tooth was significantly earlier in girls than in boys.

Table 3. Mean age and SD of primary teeth emergence in Iran

Maxilla*		**51**	**52**	**53**	**54**	**55**	**61**	**62**	**63**	**64**	**65**
		A	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Boys	Mean	276	337	543	468	748	275	336	542	464	742
	SD	62	98	92	90	99	60	90	98	84	106
Girls	Mean	298	352	562	473	744	298	357	556	481	743
	SD	73	90	86	81	107	73	105	95	100	104
Mandible*		**81**	**82**	**83**	**84**	**85**	**71**	**72**	**73**	**74**	**75**
Boys	Mean	227	369	551	483	746	227	377	556	483	741
	SD	61	100	97	91	90	64	106	90	86	101
Girls	Mean	249	393	574	486	739	244	386	578	483	742
	SD	84	101	102	86	118	76	101	103	78	124

* The tooth numbering is based on the FDI system. Maxillary central incisor: 51 and 61; Mandibular central incisor: 71 and 81; Maxillary lateral incisor: 52 and 62; Mandibular lateral incisor: 72 and 82; Maxillary canine: 53 and 63; Mandibular canine: 73 and 83; Maxillary first molar: 54 and 64; Mandibular first molar: 74 and 84; Maxillary second molar: 55 and 65; Mandibular second molar: 75 and 85.

Bilateral difference: No statistically significant difference was reported in the emergence time of teeth on the right and left sides of the jaw: no antimere was observed (Mahmoudian, Ghandharimotlagh and Khoujani, 2005).

Sequence of tooth emergence: Figure 2 shows the sequence of primary teeth eruption in Iranian children (Mahmoudian, Ghandharimotlagh and Khoujani, 2005). In Tabriz, the sequence of emergence was mandibular central incisors, maxillary central incisors and mandibular lateral incisors (Poureslami et al., 2015). Central incisors and second molars emerged earlier in the mandible than in the maxilla (Mahmoudian, Ghandharimotlagh and Khoujani, 2005).

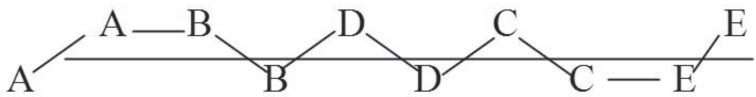

Figure 2. The sequence of primary teeth eruption in Tehran, Iran (Mahmoudian, Ghandharimotlagh and Khoujani, 2005)

Factors affecting variability in the tooth emergence pattern: A study conducted in Hamedan on 126 infants showed no significant association between the time of emergence of the first primary tooth and children's height, infant feeding practice, family income, and the mother's age (Ahmadi-Motamayel, Soltanian and Basir, 2017). In Rasht, however, a study that recruited 648 children – 288 girls and 360 boys – aged 3-15 months found a significant association between the eruption time of the first primary tooth and the weight-for-age of both girls and boys. The relationships between the age of emergence of the first primary tooth eruption and head circumference-for-age and height-for-age were only significant for boys; in boys with a weight/age index of more than 5%, the mean age of emergence of the mandibular centrals was 12.1 ± 0.21 months. The mean age of emergence was 10.8 ± 0.17 months for boys, with a weight/age index from 5% to 50%, and 9.43 ± 0.23 months for boys with a mean weight/age index that ranged from 51% to 95%. Boys with a weight/age index of more than 95% had a mean emergence time of 8.15 ± 0.55 months for the first primary tooth. The emergence of primary teeth in girls was also earlier in heavier children (Vejdani et al., 2015). The outcome of a study conducted in Tehran corroborated this finding: a negative linear correlation was found between the time of emergence of the first primary tooth and birth weight, suggesting that delayed tooth eruption is related to lower birth weight (Sajadian et al., 2010).

Also, children's use of iron supplements resulted in the earlier emergence of the first primary tooth (Vejdani et al., 2015). There was no significant correlation between the time of emergence of the first primary teeth and socioeconomic status (Poureslami et al., 2015).

Developmental Dental Hard-tissue Anomalies

Table 3 provides a summary of publications on the prevalence of developmental dental anomalies in Iran. Differences in the results within and between populations may be due to differences in sampling methods and diagnostic criteria, but they may also reflect true variability in the profile for different populations.

Yazd, Central Iran: The prevalence of developmental dental hard-tissue anomalies was 40.8%. The prevalence of individual anomalies was 15% of dilacerations; 8.3% of impaction; 7.5% of taurodontism; and 3.5% of a supernumerary tooth. The prevalence was higher in patients under 20 years of age. Taurodontism, dilacerations and supernumerary teeth were more common in males, while impacted teeth, microdontia and gemination were more common in females (Ezoddini, Sheikhha, and Ahmadi, 2007).

Hamadan, West Iran: The prevalence of developmental dental anomalies in a survey of patients aged 7 to 35 years was 29%. Of these, 78.53% were a single type of anomaly. The prevalence of anomalies of shape, number, structure, and location was 3.58%, 8.13%, 0.30%, and 23.9%, respectively. Anomalies of shape and number were more commonly present in the age groups 7 to 12 years and 13 to 15 years, whereas anomalies of structure and position were considerably more common among patients of 15 to 35 years of age. No significant gender differences were observed in the types of anomalies. There were more anomalies in the maxilla than in the mandible – 54.4% vs. 45.8%. There was no difference in the proportion of anomalies on the left and right sides of the jaw (Shokri et al., 2014).

Shiraz, Central Iran: The prevalence of developmental defects of enamel for school children, determined with the Modified Developmental Defects of the Enamel Index, was 48.2%. The prevalence was higher in children with an Apgar score at birth of less than seven and in those with illness during the first month of life. Lesions were significantly fewer in the third child in families than in the first or second child (Memarpour, Golkari, and Ahmadian, 2014).

Zahedan, Southeast Iran: The prevalence of developmental dental hard-tissue anomalies was 18.2%. The most prevalent lesions were morphological anomalies – 71.4%. The prevalence of taurodontism was 5.38%; dilacerated teeth 5.29%; tooth impaction 3.41%; dens invagination 1.37%; congenitally missing teeth 1.11%; peg lateral 0.77%; supernumerary teeth 0.51%; transposition 0.18%; fusion 0.09%; and gemination 0.09%. The prevalence of mal-positioned teeth was 19.7% (Saberi and Ebrahimipour, 2016).

Primary teeth: Only one study reported on the prevalence of developmental dental hard-tissue anomalies in the primary dentition in Iran (Afshar and Toffighidaryan, 2011). The authors examined the anomalies in primary anterior teeth and their prediction of occurrence in the permanent successors. The most prevalent anomaly reported was fusion, 34.5%; missing teeth, 34.5%; supernumerary teeth, 18.5%; and gemination, 12.5%. Most cases of fusion affected the central and lateral mandibular teeth, whereas most cases of gemination were in the maxilla. All supernumerary teeth were seen in the maxilla. There was no difference in the proportion of missing teeth in the maxilla and mandible.

Permanent teeth: Table 4 is a summary of publications on the prevalence of anomalies in tooth number in Iran. All the studies were conducted on hospital-based patients. The prevalence of hypodontia ranged from 1.11% in Zahedan (Saberi and Ebrahimipour, 2016) to 16.1% in Hamadan (Shokri et al., 2014). The largest study, covering eight provinces in Iran and including 7□35-year-old dental patients, found a prevalence of hypodontia, excluding third molars, of 10.9%. The prevalence of missing third molars was 34.8% (Sheikhi, Sadeghi, and Ghorbanizadeh, 2012).

The most common missing teeth, in no order, were the maxillary lateral incisor, mandibular second premolar, maxillary second molar and mandibular central incisor. The prevalence of hypodontia was significantly higher in patients with class III malocclusion – 45.2% – and lowest in patients with class I malocclusion – 6.4% (Dastjerdi et al., 2010). Dastjerdi et al. (2010) reported a 0.34% prevalence of oligodontia in patients in Tehran, and Shokri et al. (2014) reported no cases of oligodontia in Hamadan.

Table 3. A compilation of studies on developmental dental hard-tissue anomalies in Iran

Place of the study	Year of study	Age	Sample size	Sample population	Type of anomaly and criteria of diagnosis	% with anomaly	More prevalent anomalies	Associated factors	Reference
Yazd	2007	Two age groups: ≤20 years old >20 years old	480	Dental patients	Dental developmental anomalies	40.8%	Dilacerations Impaction Taurodontism	Gender Age group	Ezoddini, Sheikhha, and Ahmadi, 2007
Zahedan	2012	6-9 years old	433	School children	Developmental Defects of the Enamel Index used to identify molar incisor hypomineralization	12.7%	-	Mother and child's medical histories during the prenatal, perinatal and postnatal periods Postnatal factors such as renal failure, chicken pox, asthma and allergic reactions and the use of amoxicillin	Ahmadi, Ramazani, and Nourinasab, 2012

Place of the study	Year of study	Age	Sample size	Sample population	Type of anomaly and criteria of diagnosis	% with anomaly	More prevalent anomalies	Associated factors	Reference
Shiraz	2014	9-11 years old	810	School children	Molar incisor hypomineralization criteria adapted from the European Academy of Paediatric Dentistry	20.2 %	-	Gender Body weight and height Father's education Socioeconomic status	Ghanim et al., 2014
Shiraz	2014	9-11-year-old children	974	School children	Modified Developmental Defects of Enamel Index	48.2%	-	No gender difference Apgar score at birth <7 Illness during the first month Order of child in the family	Memarpour, Golkari , and Ahmadian , 2014
Hamadan	2014	7-35 years old	1,649	Dental patients	Dental developmental anomalies	29%	Impaction Dilacerations Hypodontia	More common in maxilla No gender difference Age group	Shokri et al., 2014
Zahedan	2016	>16 years	1,172	Dental patients	Dental developmental anomalies	18.2%	Taurodontism Dilacerations Impaction	No gender difference	Saberi and Ebrahimipour, 2016

Supernumerary teeth: The prevalence of supernumerary teeth ranged from 0.51% in Zahedan, in the southeast of Iran (Saberi and Ebrahimipour, 2016), to 2.43% in Hamadan, in the west of Iran (Shokri, 2014) and 3.5% in Yazd, Central Iran (Ezoddini, Sheikhha, and Ahmadi, 2007).

Microdontia: In a study conducted in the southeast of Iran, the prevalence of a peg lateral tooth was 0.8% (Saberi and Ebrahimipour, 2016). In Yazd, the prevalence of microdontia was 2.5%, and females had significantly more microdontia than males (Ezoddini, Sheikhha, and Ahmadi, 2007).

Taurodontism: The prevalence ranged from 3.34% in Hamadan (Shokri et al., 2014) to 5.4% in Zahedan, in southeast Iran (Saberi and Ebrahimipour, 2016), and 7.5% in Yazd (Ezoddini, Sheikhha, and Ahmadi, 2007). A comprehensive study of taurodontism, by using panoramic radiographs of 2,360 dental patients from eight cities in Iran (Urmia, Karaj, Sari, Qazvin, Isfahan, Zahedan, Ahvaz and Yazd), reported a prevalence of 22.9%, with 8.84% of molars affected. No significant gender difference was found, and the lesion was more prevalent in the maxilla than in the mandible. The prevalence was highest in the maxillary second molars, mandibular second molars, maxillary first molars and mandibular first molars, in that order (Jamshidi et al., 2017). Also, Sari and Karaj had the highest prevalence of taurodontism, and significantly less prevalence in Ahwaz and Zahedan (Jamshidi et al., 2017).

Dens invagination: Prevalence ranged from 0.24% in Hamadan (Shokri et al., 2014) to 0.8% in Yazd (Ezoddini, Sheikhha, and Ahmadi, 2007) and 1.4% in Zahedan, in southeast Iran. It occurs bilaterally in 75% of cases (Saberi and Ebrahimipour, 2016).

Dilaceration: Prevalence of the lesion differs by study location: 5.3% to 3% in females and 2.4% in males – in Zahedan (Saberi and Ebrahimipour, 2016); 7.6% in Hamadan (Shokri et al., 2014); and 15% in Yazd (Ezoddini, Sheikhha, and Ahmadi, 2007). In Yazd, the prevalence was significantly higher in males than in females (Ezoddini, Sheikhha, and Ahmadi, 2007). In a study of root dilacerations in 250 dental patients in Shiraz, using full-mouth periapical radiographs, the prevalence was 7.2%. Tooth level prevalence was 0.3%. The lesion was equally distributed in the maxilla and mandible, though more prevalent in the posterior teeth. The mandibular second molar was the most frequent dilacerated tooth (1.6%), followed by the maxillary first molar (1.3%) and the mandibular first molar (0.6%) (Nabavizadeh et al., 2013).

Fusion and gemination: Saberi and Ebrahimipour (2016) found a prevalence of 0.09% in a southeast Iranian population. The prevalence did not differ by gender. Shokri et al. (2014) found no case of fusion in Hamadan. In Yazd, the prevalence of gemination was 2.1%, and the prevalence of fusion was 0.2% (Ezoddini, Sheikhha, and Ahmadi, 2007).

Talon cusp: The only study that reported on the prevalence of Talon cusps was that of Ezoddini, Sheikhha, and Ahmadi (2007). The study was conducted in Yazd. A prevalence of 0.6% was reported.

Molar-incisor hypomineralization: Ezoddini, Sheikhha, and Ahmadi (2007) examined 433 children aged 7-9 years in Zahedan, in southeast Iran and reported a prevalence of 12.7%, with no significant gender difference. Mothers of children with molar incisor hypomineralization and children with the lesion had significantly more prenatal, perinatal and postnatal medical events than children without the lesion. Postnatal predisposing factors were renal failure, chicken pox, asthma, allergic reactions, and the use of amoxicillin (Ahmadi, Ramazani, and Nourinasab, 2012). Prolonged breastfeeding was associated with an increased prevalence of molar incisor hypomineralization (Ahmadi, Ramazani, and Nourinasab, 2012).

The prevalence of molar incisor hypomineralization was high in Shiraz. The prevalence was 20.2% in a study conducted among 810 children, aged 9 to 11 years. Of these, all the first molars were affected in 53.7%. The prevalence was significantly higher in girls, in children with appropriate body weight-for-height, and children from families with low socioeconomic status. On regression analysis, none of these associations were statistically significant. Children with obesity had a lower risk for molar incisor hypomineralization (Ghanim et al., 2014).

Amelogenesis imperfecta, dentinogenesis imperfecta and dentine dysplasia: A study conducted in Hamadan, in eastern Iran, reported a prevalence of 0.24% for amelogenesis imperfecta and 0.06% for dentine dysplasia. No case of dentinogenesis imperfecta was identified (Shokri et al., 2014).

Table 4. Publications on the prevalence of congenitally missing teeth in children in Iran

Place of the study	Year of the study	Age	Sample size	Sample type	Prevalence (%)	The most common missing tooth types	Gender dimorphism	Bilateral: unilateral	Maxilla: mandible	Anterior: posterior
Tehran (Amini, Rakhshan, and Babaei, 2012)	2012	10-20 years old	3,374	Orthodontic patients Excluding third molar	5.2%	Maxillary lateral incisor Mandibular second premolar Mandibular central incisor	not statistically significant	Bilateral was more prevalent	not statistically significant	not statistically significant
Tehran (Dastjerdi et al., 2010)	2010	9-27 years old	1,751	Orthodontic patients Excluding third molar	9.1%	Maxillary lateral incisors Maxillary second premolars Mandibular lateral incisors	not statistically significant (slightly more in females)	NM*	more prevalent in the maxillary arch	higher in the anterior region than in the posterior segment
Mashhad (Ajami, Shabzendedar, and Mehrjerdian, 2010)	2010	9-14 years old	600	Dental patients Excluding third molar	9.0%	Mandibular second premolars Maxillary lateral incisors Mandibular central incisors	not statistically significant (slightly more in females)	NM	not statistically significant	NM

Place of the study	Year of the study	Age	Sample size	Sample type	Prevalence (%)	The most common missing tooth types	Gender dimorphism	Bilateral: unilateral	Maxilla: mandible	Anterior: posterior
Eight provinces of Iran (Sheikhi, Sadeghi, and Ghorbanizadeh, 2012)	2012	7□35 years old	2,422	Dental patients Excluding third molars	10.9%	Mandibular second premolars Maxillary second premolars Maxillary lateral incisors	not statistically significant	Bilateral was more prevalent	more prevalent in the maxillary arch	NM
Zahedan (Saberi and Ebrahimipour, 2016)	2016	>16 years old	1,172	Dental patients	1.11%	Maxillary lateral incisor Mandibular second premolar Mandibular lateral incisor	not statistically significant	NM	NM	NM
Hamadan (Shokri et al., 2014)	2014	7-35 years old	1,649	Dental patients Including third molars	16.07%	Maxillary lateral incisors Mandibular second premolar Maxillary second premolar	not statistically significant	NM	NM	NM

Dental fluorosis: The prevalence of fluorosis in Iran is high. The 18 studies on dental fluorosis included only some regions of the country; data are still missing from a significant proportion of the country. So, the results on the national prevalence of fluorosis are inconclusive. In children aged 5 to 12 years resident in Maku city (Azerbaijan-e-Gharbi Province), where the fluoride concentration in water is about 6.8-7.0 mg/l – the highest concentration in Iran – the prevalence of fluorosis was 100%. An assessment of types of fluorosis using the Dean's Index, showed that 28% of children had normal fluorosis, and 5% had a severe form of the lesion (Taghipour et al., 2016). Also, Azami-Aghdash et al. (2013) reported a prevalence of fluorosis of 61%, with only 1% severe fluorosis.

Tooth impaction and tooth transposition: The reported prevalence of tooth impaction in southeast Iran was 3.41%, and that of tooth transposition was 0.18% (Saberi and Ebrahimipour, 2016). The prevalence was highest for the maxillary canine (Saberi and Ebrahimipour 2016). Tooth transposition occurred in both the mandible and maxilla, and there was no gender difference in its occurrence (Saberi and Ebrahimipour 2016). In Hamadan, east of Iran, the prevalence of tooth impaction was 16.1%, while that of tooth transposition was 0.24% (Shokri et al., 2014).

Gaps and Recommendations

There are few cross-sectional studies on the prevalence of developmental dental hard-tissue anomalies in the primary dentition in Iran. There are also no longitudinal studies on the prevalence of developmental dental hard-tissue anomalies in both the primary and permanent dentition. Longitudinal studies are required to help establish the true profile of developmental dental hard-tissue anomalies in Iranian children, including the emergence profile of the primary and permanent dentitions and risk factors for developmental dental hard-tissue anomalies.

Amiri et al. (2018) reported that the permanent teeth in children in Tehran emerged earlier than in children in Nigeria, Australia, USA and Turkey (Savara and Steen, 1978; Diamanti and Townsend, 2003; Wedl et al., 2004; Oziegbe, Esan and Oyedele, 2014). However, the permanent teeth of children in Shiraz emerged later than those of children in Africa and Japan (Banakar, Zarrindast and Sabetahd, 2000). These observed differences, and the differences in the emergence time among regions in Iran, could be due to differences in the sampling and dating methodology, and bias in the accuracy of dates of birth. On the other hand, there could be a true difference, resulting from associated genetic and environmental factors of the populations. Use of radiographic assessments may help reduce some of the confounder introduced reporting bias in epidemiological studies. There are, however, ethical challenges with the use of radiographs for epidemiological surveys.

More studies are also needed to help identify the prevalence of some developmental dental hard- tissue anomalies affecting tooth structure and tooth position in both the primary and permanent dentition. Such data will enable comparisons between regions and the various populations in Iran. Comparisons of results within and between countries can be enhanced through the development of global dental hard-tissue anomalies' screening tools. Population-based surveys, rather than hospital-based surveys should be encouraged to further reduce the introduction of sample bias in studies. Finally, studies on developmental dental hard-tissue anomalies should not enroll children younger than 12 years old, as the calcification of teeth is usually completed at that age, especially in boys.

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Israel

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Background on Israel

The state of Israel was established in 1948. Since then, Jewish immigrants from all over the world have come to the country (The Jewish Agency for Israel website). In the first year after its independence, 203,000 people moved to this new country. The first few years brought Jewish communities from Bulgaria, Libya, Yemen, Iraq and Romania, as well as holocaust survivors. From 1952 to 1967, more newcomers came to Israel from North Africa (Morocco, Tunis and Egypt). Between 1984 and the late 1990s there were immigration waves of small numbers of Jews from Ethiopia, and in the 1990s there was an immigration wave of Jews from the former Soviet Union. Overall, about one million Jews immigrated to Israel in the period 1990-2000. Because of these immigration waves, the Israeli population changed. Figure 1 is a map of Israel showing its relationship with its border countries.

Israel's total population at the end of 2016 was 8.63 million, of which 2.798 million were children aged 0 to 17 years (The Israeli Society/the future generation of Israel, Central Bureau of Statistics). Of the children, 71.3% were Jews, 25.7% were Arabs (Muslims, Christians and Druze), and 3% were other nationalities. The population of children under 18 years old was 35%. Even though Israel has a relatively small population, its diverse ethnic groups have unique socio-demographic and cultural characteristics. Groups such as ultra-orthodox Jews, Bedouins and others, have large families. Every group has unique beliefs, traditions, and

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genetics. These features might influence the tendency to develop different hard dental-tissue anomalies.

Figure 1: Map of Israel

Sequence and Timing of Eruption of Permanent Dentition

In 1969-1970, a sample of 2,116 Israeli children (1,076 boys and 1,040 girls) was surveyed to investigate the eruption profile of the permanent dentition, exclusive of the third molar (Koyoumdjisky-Kaye et al., 1977). The eruption sequences for boys and girls were:

$M^1\ M_1\ I_1\ I^1\ I_2\ I^2\ P^1\ P_1\ C\downarrow\ P^2\ M_2\ C\uparrow\ P_2\ M^2$ for boys
$M^1\ M_1\ I_1\ I^1\ I_2\ I^2\ P^1\ C\downarrow\ P_1\ C\uparrow\ P^2\ P_2\ M_2\ M^2$ for girls

At the time the incisor started to emerge, the first permanent molars had reached the occlusal plane. The maxillary first molar was the first permanent tooth to erupt, followed by the mandibular first molar. Maxillary and mandibular incisors and canines erupted somewhat later in Israeli children than they did in other populations (Koyoumdjisky-Kaye et al., 1977). The sequence of emergence of permanent teeth was virtually identical in both genders, except for the canines. The mandibular canine erupted before the mandibular first premolar in girls and after it in boys. The maxillary canine erupted before the maxillary second premolar in girls and after it in boys.

All dental stages of tooth eruption were initiated and terminated earlier in girls than in boys. The gender difference in the timing and rapidity of dental maturation increased with advancing dental stages in the entire dental arch; girls had an earlier onset of each dental stage and a shorter interval of dental development.

The timing and sequence of the emergence of the permanent dentition were studied in a sample of 2,116 children of seven ethnic groups. The ethnic groups were Cochin Jews, North-Africa Jews, Yemen Jews, Kurdistan Jews, Eastern-Europe Jews, Druse, and Circassians. The time of onset of the dental stages was uniform among these groups. Differences among the groups were fewer than the intragroup variabilities of each ethnic group (Koyoumdjisky-Kaye, Baras and Grover, 1981).

Prevalence of Developmental Dental Hard-tissue Anomalies

Hypodontia

The first survey on the prevalence of hypodontia was conducted between 1962 and 1963 by Rosenzweig and Garbarski (1965) from the Department of Preventive Dentistry, Hebrew University-Hadassah School of Dental Medicine in Jerusalem. They examined 28,000 students every year (1962-1963) in elementary schools in the city of Jerusalem. When a case of missing tooth was suspected, it was validated through radiographic examination. Mothers were interviewed to exclude a history of previous extractions. The prevalence of hypodontia was determined for six paternal birth regions: the Near East (Turkey, Syria, Lebanon, and Egypt), North Africa (Algeria, Tunis, Morocco, and Libya), Europe and America, Iraq and Iran, Yemen and Aden, and Israel.

Of the study population, 83 (0.3%) children had agenesis of 155 permanent teeth. Three of these children had a combination of missing teeth and supernumerary teeth. The lowest prevalence of hypodontia was found in children whose fathers were born in Israel. The highest prevalence of hypodontia was found in children with fathers from Yemen, the Middle East, and North Africa. In all groups, the most affected tooth was the lateral incisor; it was missing bilaterally in 58% of cases and unilaterally in 42%. Ninety-five lateral incisors were missing in the maxilla and 48 in the mandible. Across all groups, most cases of hypodontia affected a single tooth. There was no significant difference in the number of missing teeth between the right and left sides of the jaw.

Chosack, Eidelman and Rosenzweig (1973) investigated the prevalence of hypodontia in Israeli Jewish populations. The authors examined 10,371 males and 11,013 females aged 12-18 years. The prevalence of hypodontia was 4.6%, and there was no significant difference in prevalence between genders. The upper lateral incisor was missing in 2.11% of the population; females had a significantly higher prevalence of a missing lateral incisor than males. Second premolars were missing in 1.87% of the population, with no significant gender differences. Also, the lower incisor was missing in 0.68% of the children, with a higher prevalence in males.

Chosack, Eidelman and Cohen (1975) investigated the heredity of hypodontia in Israeli Jews. Parents and siblings, aged 12 years and older, of 305 randomly selected children from the aforementioned hypodontia study (Chosack, 1973) were evaluated. Hypodontia of the same group of teeth as that of the probands was observed in 11.8% of 820 first-degree relatives (comprised of 449 parents and 371 siblings). The prevalence was 14.8% in the siblings and was significantly higher than that observed in the general population. The prevalence of missing maxillary lateral incisors among 426 first-degree relatives of probands was 10.3%, compared with 2.11% in the general population. The study concluded that polygenicity is an inheritance model for hypodontia. The risk of having hypodontia in first-degree relatives is greater than that of the general population, but less than that expected through the effects of a single gene.

Goren et al. (2005) investigated the prevalence of hypodontia in a population of 280 Israeli recruits to the Israeli defense forces through a review of their panoramic radiographs. The participants were randomly selected 18-year-old men. Extraction of any tooth was precluded. The prevalence of hypodontia, inclusive of third molars, was 43.8%. When the third molar was excluded, the prevalence of hypodontia was 5.3%. The prevalence was 4.2% for a missing mandibular second premolar; 1.1% for missing maxillary laterals, of which one case was bilateral; 7.6% for a missing mandibular third molar; 4.9% for a bilaterally missing maxillary third molar; and 3.4% for a total absence of third molars.

Hyperdontia

In the survey of 28,000 school children conducted by Rosenzweig and Garbarski (1965), 21 (0.1%) school children had 36 supernumerary teeth. Jewish children of oriental origin had a higher prevalence of hyperdontia than Jewish children of European and Israeli origin. Of the 36 supernumerary teeth, 32 were in the maxilla, 26 were mesiodens, four resembled the lateral incisor morphologically, and two were peg-shaped supernumerary laterals. Three of the four supernumerary mandibular teeth were extra central incisors, whereas the fourth was a third premolar. 25 (69.4%) of the 36 supernumerary teeth were in boys, significantly more hyperdontia was found in boys than in girls, and 24 of the teeth (67%) were identified radiographically.

Zilberman, Malron and Shteyer (1992), of the Hadassah Medical Center in Jerusalem, assessed 100 children with supernumerary teeth in the premaxillary region. Of 130 supernumerary teeth, 122 were surgically removed. At the time of surgery, about 50% of these children were aged 7-9 years, 15% were less than 7 years old, and the remainder were older than 9 years. Most (73%) of the extracted teeth were developed in the direction of natural eruption, 26% were grown nasally, and one tooth was positioned horizontally. Also, 78% of the supernumerary teeth were unerupted, the majority of which were located palatally. The most common shape of the supernumerary tooth was conical (61%).

Infant Oral Mutilation – Canine Bud Removal

Infant oral mutilation is performed for perceived medical benefit; a common belief in many rural areas in Africa is that unerupted primary canines cause diarrhea, vomiting and fever. Thus, the primary canine buds are removed in infants; the procedure is carried out by traditional healers, using fingernails or sharp instruments. The extraction leads to heavy bleeding, infection, inflammation, and acute suffering. It also generates dental defects in the successor permanent teeth, or in the primary canine and the adjacent primary teeth, if the bud is incompletely extracted (Johnston et al., 2005).

More than 40,000 Ethiopian Jews have immigrated to Israel from Ethiopia in the last 30 years (http://www.jewishagency.org/he/ethiopian-aliyah/program/8921). In a study conducted by Holan and Mamber (1994), canine bud extraction was evident in 35/59 (59.3%) Ethiopian Jewish children, aged 3-12 years, who immigrated to Israel in 1991. Sixty-three primary canines were missing – 47 (75%) mandibular and 16 (25%) maxillary. Severe hypoplastic defects were observed in another 19 mandibular primary canines. In addition to hypoplasia of the primary canines, many abnormalities were observed in children who had had one or more canine buds removed: missing mandibular primary lateral incisors, hypoplasia of an adjacent primary and permanent tooth, dilaceration of primary canines, retention of primary lateral incisors, with distal eruption of the permanent successors, failure of development of the permanent canine, displacement and impaction of the permanent canine, and midline shift.

In a cross-sectional study, conducted during the years 2005-2008, Davidovich et al. (2013) compared the prevalence of missing primary canines and dental defects in Israeli offspring of immigrants from Ethiopia to that of offspring of native Israelis living in the same neighborhoods. The authors examined 794 children, 477 of Ethiopian descent and 317 offspring of native Israeli parents. Intact canines were present in more children of native Israelis than in children of Ethiopians. Missing/hypoplastic canines were present in more children of Ethiopians than children of native Israelis; this distribution was seen in children aged 18-48 months (57.7% versus 12.5%) and aged 49-82 months (59.6% versus 7.4%). These observed differences were highly significant. The study revealed that traditional canine bud removal was practiced by Ethiopian immigrants in Israel as frequently as it was in Ethiopia.

Fusion and Gemination

Pre- and post-treatment facial and intraoral photographs, study models, and panoramic and periapical radiographs of 574 patients from the Department of Orthodontics, Tel Aviv University, were examined by Finkelstein et al. (2015) for the presence of fusion or gemination in the maxillary anterior region. The mean patient age was 13.3 years. Eight patients (six males and two females) had nine fused or geminated teeth in the maxillary anterior region. The prevalence of fusion was 1.4%. Eight (88.9%) of the nine lesions were unilateral, four were on the left side, and four were on the right side. One case was bilateral. Males were more affected than females, in a ratio of 3:1. All fused or geminated teeth were in the permanent dentition.

Tetracycline Pigmentation

In the 1960s, tetracycline was used widely in pediatric medicine, particularly in the treatment of upper respiratory infections (Gibson et al., 1964). Tetracycline pigmentation of the teeth follows administration of the drug during tooth development. The prevalence of tetracycline-stained teeth was studied in 965 5-year-olds in West Jerusalem by Zadik and Eidelman (1975). The prevalence was 0.8%. Tetracycline-stained teeth were significantly more prevalent in children of lower socioeconomic status, probably due to poorer living conditions that were associated with a higher prevalence of upper respiratory infections, which, in turn, increased the use of tetracycline therapy. Nowadays, physicians avoid tetracycline therapy in pregnant women and preschool children.

Amelogenesis Imperfecta

Amelogenesis imperfecta was detected in nine of 70,359 6-18-year-old school children surveyed by Chosack et al. (1979), a prevalence approximating 1:8000. Of these cases, eight were the hypoplastic type, and one was the snow-capped hypo-maturation type. Family studies demonstrated that hypoplastic amelogenesis imperfecta was an autosomal dominant trait in two children and an autosomal recessive trait in six children. Three additional families with amelogenesis imperfecta were referred to the pediatric dentistry clinic, of which two had the autosomal recessive hypoplastic type, and one had the hypocalcified type, inherited in an autosomal dominant pattern. A new type of local hypoplastic autosomal recessive amelogenesis imperfecta was observed in four families: it is characterized by horizontal pitting and grooving, which is more pronounced in the middle third of the crowns of most teeth in both dentitions. Amelogenesis imperfecta is more common in the Jewish population of Israel than in the United States; Witkop (1976) reported a prevalence of all forms of amelogenesis imperfecta of 1:14,000-16,000 in the United States.

Fluorosis

Zusman et al. (2005) investigated the prevalence of fluorosis in 1,327 study participants as part of a national survey that gathered epidemiological information on the caries prevalence and treatment needs of Israeli 12-year-olds. The prevalence of fluorosis of all grades was less than 12%. The prevalence of moderate and severe fluorosis was 1%. The presence of fluorosis was not associated with the level of fluoride in drinking water. Gender differences in the prevalence of fluorosis were not observed.

Two groups of children, 182 aged 15-16 years and 152 aged 6-8 years, who had resided in the same community from birth with 5 ppm fluoride in the drinking water, were examined over a two-year period (Mann et al., 1987, Mann et al., 1990). The proportion of children having fluorosis was determined by the use of the Dean's Index. In the 15-16-year-old group, the prevalence of fluorosis was 100%: 53 participants had mild fluorosis, 83 had moderate fluorosis, and 46 had severe fluorosis. No participants had normal, questionable, or very mild fluorosis. A statistically significant positive association was found between the prevalence of caries and fluorosis: the more severe the fluorosis, the higher was the prevalence of caries. Significantly more boys than girls had higher levels of fluorosis.

In the 6-8-year-old group, 60% of children had mild fluorosis in both the primary and permanent dentition, 40% had moderate/severe fluorosis, and 4 had no signs of fluorosis. Also, 14 (9.2%) children had more severe fluorosis in the primary dentition and 41 (26.9%) children had more severe fluorosis in the permanent dentition. The rate of caries increased with increasing fluorosis severity in the permanent dentition; this trend was not observed with the primary dentition.

Pre-eruptive Intracoronal Resorption

Pre-eruptive intracoronal lesions are caries-like lesions that appear in unerupted teeth. They are often located within the dentine, adjacent to the dentino-enamel junction. Umansky et al. (2016) conducted a retrospective study of 335 panoramic and bitewing radiographs; 13 (3.9%) pre-eruptive lesions were detected.

Gaps and Recommendations

Most of the epidemiologic studies of hard-tissue anomalies in Israel were conducted a few decades ago. Israel’s population has changed a lot during the years due to immigration waves and the greater growth of some groups than of others. Updated epidemiologic studies should be performed so that the present status of various dental anomalies can be better understood.

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JORDAN

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Background on Jordan

The Hashemite Kingdom of Jordan is on the east bank of the Jordan River as shown in Figure 1. The land area is 89,318 km^2 and the total population was 9,798,000 as of November 18, 2016 (Department of Statistics, 2016). According to the 2015 statistics, 42.0% of the population reside in the capital, Amman, 18.6% in Irbid, and 14.3% in Zarqa (Department of Statistics, 2016). Figure 1 highlights the political structure of Jordan.

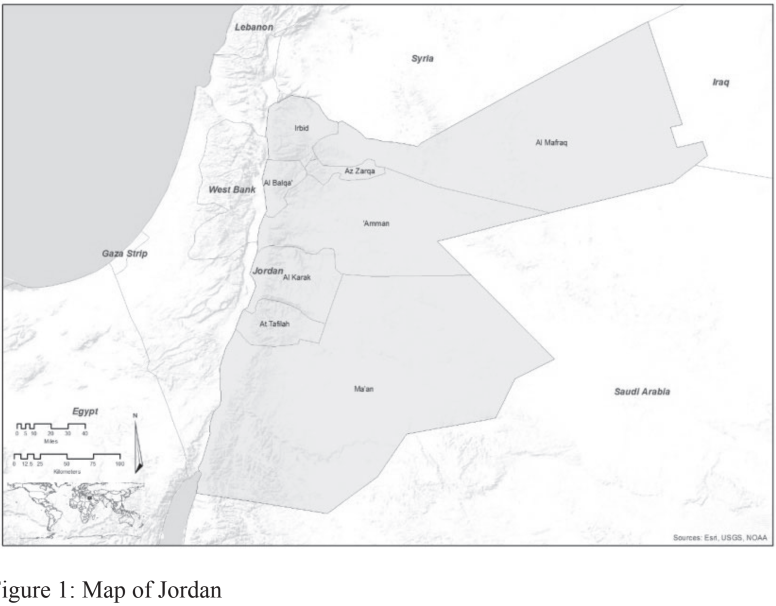

Figure 1: Map of Jordan

Jordan's estimated annual population growth rate is 2.4%, and 34.3% of the population is less than 15 years of age (Department of Statistics, 2016). Infant mortality is 17 per 1000 live births, and mortality for the under-5-years population is 19 per 1000. Life expectancy is 74 years for women and 72.8 years for men. The GDP per capita is nearly $2,801 and the poverty ratio is 14.4% (Department of Statistics, 2016). The allocation for the Ministry of Health to address all health issues including oral health was 7.7% of the total government budget in 2015 (Department of Statistics, 2016).

A high proportion of (30.6%) Jordanians work as services and sales workers, 24.6% as professionals, and 44.8% on other jobs (Department of Statistics, 2016). A very high proportion of the population (93.2%) is literate, with 15.2% holding Bachelor's degrees or above (Department of Statistics, 2016). Medicine-related professionals consist mainly of nurses (7,987) and physicians (4,798). There are about 782 dentists (Department of Statistics, 2016), among whom 73 are registered pediatric dentists (Jordan Dental Association, 2016).

Timing and Sequence of Emergence of Primary Dentition

The timing and sequence of emergence of primary teeth in Jordanian children were determined by Al-Batayneh et al. (2015), who examined 1,988 (885 female and 1,103 male) children aged 1 to 45 months from the northern, middle and southern regions. The median age of emergence for all primary teeth was symmetrical on both sides of the jaw and so only the emergence time of teeth on the right side was reported. Teeth emerged earlier in females than in males, but the differences were not significant. Table 1 presents the median ages (with the fifth and ninth percentiles, standard deviations and standard errors) of emergence of each right-side primary tooth for male and female study participants. The emergence sequence, as shown in Table 2, was the same in the mandible and the maxilla for the central incisor and lateral incisor, first molar, canine and second molar (Al-Batayneh et al., 2015). A substantial increase in weight was associated with earlier emergence of the primary lateral incisors and upper central incisor. Otherwise, no emergence sequence pattern was associated with weight and height (Shaweesh and Al-Batayneh, 2018).

Table 1. Timing of emergence of primary teeth in Jordanian children by months (Al-Batayneh et al., 2015) [NS-non-significant]

Tooth	All			Males			Females			M_Males - M_females	Stat. Sig of M-F
	Median (Months)	Percentile		Median (Months)	Percentile		Median (Months)	Percentile			
		5th	95th		5th	95th		5th	95th		
Upper right central incisor	10.5	5.0	16.0	10.5	5.1	15.8	10.6	4.9	16.3	-0.1	NS
Upper right lateral incisor	13.0	7.3	18.6	12.9	7.2	18.5	13.1	7.5	19.0	-0.2	NS
Upper right canine	20.3	14.2	26.4	20.6	14.3	26.9	19.8	14.3	25.4	0.8	NS
Upper right first molar	15.5	10.8	20.2	15.5	11.3	19.7	15.5	10.2	20.9	0.0	NS
Upper right second molar	27.5	20.5	34.4	27.7	20.5	35.0	27.2	20.5	33.8	0.5	NS
Upper left central incisor	8.6	3.1	13.4	8.3	3.6	13.1	8.1	2.6	13.6	0.2	NS
Upper left lateral incisor	14.3	7.7	20.8	14.6	7.6	21.5	13.9	7.9	19.8	0.7	NS
Upper left canine	20.4	14.5	26.4	20.9	14.8	27.0	19.8	14.4	25.2	1.1	NS
Upper left first molar	16.0	11.1	20.9	16.1	11.7	20.6	15.8	10.3	21.4	0.3	NS
Upper left first molar	27.5	20.1	34.8	27.7	20.0	35.5	27.2	20.3	34.0	0.5	NS

Teething disturbances were the only eruption anomalies investigated (Owais et al., 2010). A cross-sectional study was conducted to assess parental beliefs and practices about teething signs and symptoms. Almost 75% of the participants incorrectly attributed fever, diarrhea and sleep disturbances to teething, and more than 50% believed that systemic symptoms were not related to the teething process. More than 50% of the participants allowed their children to bite on chilled objects, 76.1% used systemic analgesics, and 65.6% rubbed the gums with topical analgesics to relieve symptoms presumed to be associated with teething (Owais et al., 2010).

Table 2. The intermaxillary order, the maxillary order and the mandibular order of primary tooth emergence in Jordanian children (Al-Batayneh et al., 2015)

Order	Intermaxillary order	Maxillary order	Mandibular order
1st	Lower right central incisor	Upper right lateral incisor	Lower right central incisor
2nd	Upper right central incisor	Upper right lateral incisor	Lower right lateral incisor, Lower right first molar
3rd	Upper right lateral incisor, Lower right lateral incisor	Upper right first molar	Lower right canine
4th	Lower right lateral incisor, Upper right first molar, Lower right first molar	Upper right canine	Lower right second molar
5th	Upper right canine, Lower right canine	Upper right second molar	
6th	Upper right second molar, Lower right second molar		

Timing and Sequence of Emergence of Permanent dentition

Shaweesh (2012) examined the permanent teeth in 1,240 males and 1,432 females aged 4-16 years from the northern, middle and southern regions of Jordan to determine the time of emergence of each of the permanent teeth. They found no statistically significant difference in the time of emergence of teeth on the left and right side. Also, mandibular teeth emerged earlier than the corresponding maxillary teeth, although the difference in eruption time was not statistically significant. Teeth emerged earlier in females than in males, although the gender difference was not statistically significant for the first molars and central incisor. Differences in the median age of emergence of teeth in children resident in urban and rural Jordan were not significant, except for the maxillary canine and premolars in males; the age of emergence was earlier in urban than in rural areas (Shaweesh et al., 2011). Tables 3 and 4 show the timing and sequence of emergence of permanent teeth in Jordanian children, respectively.

Developmental Dental Hard-tissue Anomalies

Studies on hard dental-tissue anomalies in Jordan have been mostly cross-sectional, retrospective or case reports. Appendices 1, 2, 3 and 4 summarize studies on anomalies of tooth number, size, shape and tooth structure. The design, prevalence and main findings of the studies are indicated.

Anomalies of Tooth Number (Appendix 1)

Agenesis: Most studies in Jordan were either prevalence studies or case reports. Cases reported that highlighted syndromes such as Ehlers Danlos syndrome (Yassin and Rihani, 2006), ectodermal dysplasia (Khabour et al., 2010) and cleft lip and palate (Al-Jamal et al., 2010) were associated with tooth agenesis.

Supernumerary teeth: Studies reported an association between supernumerary teeth and cleft lip and palate (Yassin and Hamori, 1999; Al-Jamal et al., 2010). There was a gender difference in the prevalence of supernumerary teeth in non-syndromic individuals, with a predilection in males (Yassin and Hamori, 1999; Rajab and Hamdan, 2002; Fnaish et al., 2011).

Table 3. Time of emergence of permanent teeth in Jordanian children in years (Shaweesh, 2012)

Tooth		Total Sample			Males			Females			- F_ M-F	Stat. Sig of M-F
		M (SD)	**Percentile** 5th	95th	**M (SD)**	**Percentile** **5th**	**95th**	**M (SD)**	**Percentile** 5th	95th		
Maxillary	**Central incisor**	7.2 (0.8)	5.8	8.6	7.3 (0.9)	5.8	8.7	7.1 (0.8)	5.9	8.4	0.1	NS
	Lateral incisor	8.3 (1.1)	6.5	10.1	8.5 (1.2)	6.5	10.4	8.1(0.4)	6.5	9.6	0.4	Sig
	Canine	11.3 (1.5)	8.9	13.7	11.6 (1.5)	9.1	14.0	11.1 (1.4)	8.7	13.3	0.5	Sig
	First premolar	10.2 (1.5)	7.8	12.7	10.5 (1.5)	8.0	12.9	10.0 (1.4)	7.7	12.4	0.4	Sig
	Second premolar	11.2 (1.5)	8.7	13.6	11.4 (1.5)	8.9	13.9	11.0 (1.5)	8.5	13.5	0.4	Sig
	First molar	6.3 (0.8)	5.0	7.5	6.4 (0.7)	5.3	7.5	6.2 (0.9)	4.8	7.6	0.2	NS
	Second molar	12.4 (1.4)	10.1	14.7	12.6 (1.4)	10.3	14.9	12.3 (1.4)	10.0	14.7	0.3	Sig
Mandibular	**Central incisor**	6.4 (0.8)	5.2	7.6	6.5 (0.7)	5.4	7.6	6.3 (0.8)	5.0	7.7	0.2	NS
	Lateral incisor	7.4 (0.9)	6.0	8.9	7.5 (0.9)	6.1	9.0	7.3 (0.9)	5.9	8.7	0.2	Sig
	Canine	10.2 (1.4)	8.0	12.5	10.6 (1.4)	8.3	13.0	9.8 (1.2)	7.9	11.8	0.8	Sig
	First premolar	10.3 (1.4)	8.0	12.7	10.5 (1.5)	8.1	13.0	10.1 (1.4)	7.8	12.4	0.4	Sig
	Second premolar	11.4 (1.6)	8.9	14.0	11.7 (1.6)	9.1	14.3	11.2 (1.6)	8.7	13.7	0.5	Sig

Tooth		Total Sample			Males			Females			- F_ M-F	Stat. Sig of M-F
		M (SD)	**Percentile**		**M (SD)**	**Percentile**		**M (SD)**	**Percentile**			
			5th	95th		**5th**	**95th**		5th	95th		
	First molar	6.2 (0.8)	4.9	7.5	6.2 (0.7)	5.2	7.3	6.1 (0.9)	4.7	7.5	0.2	NS
	Second molar	11.9 (1.5)	9.5	14.3	12.2 (1.4)	9.9	14.5	11.7 (1.5)	9.1	14.2	0.5	Sig

Sig – significant; NS – non-significant

Table 4. The intermaxillary order, the maxillary order and the mandibular order of permanent tooth emergence in Jordanian Children (Shaweesh, 2012)

Order	**Intermaxillary order**	**Maxillary order**	**Mandibular order**
1st	Mandibular first molar; maxillary first molar; mandibular central incisor	First molar	First molar; central incisor
2nd	Maxillary central incisor	Central incisor	Lateral incisor
3rd	Mandibular lateral incisor	Lateral incisor	Canine, first premolar
4th	Maxillary lateral incisor	First premolar	Second premolar
5th	Mandibular canine, maxillary first premolar, mandibular first premolar	Second premolar, canine	Second molar
6th	Maxillary second premolar, maxillary canine, mandibular second premolar	Second molar	
7th	Mandibular second molar		
8th	Maxillary second molar		

Anomalies of Tooth Size (Appendix 2)

Microdontia: Males had significantly larger teeth than females (Hattab et al., 1996, Shaweesh, 2017) and vice versa (Al-Khateeb and Abu Alhaija, 2006). Skeletal profile was also associated with tooth size: children with Class III malocclusion had larger teeth than the other occlusal categories (Al-Khateeb and Abu Alhaija, 2006).

Anomalies of Tooth Shape (Appendix 3)

Most studies on dental anomalies of tooth shape in Jordan were on taurodontism, peg-shaped teeth, dens invaginatus, crown morphologic abnormalities (peg-shaped teeth, hypodontia, excess mamelons, malformed premolars, T-shaped incisors, incisor fissure, and fusion), enamel pearls and dilacerations. Most of the studies reported gender, arch, and tooth differences for these anomalies (Darawzeh and Hamasha, 2000; Hamasha and Al-Omari, 2004; Al-Bashaireh and Khader, 2006; Rawashdeh and Sirdaneh, 2009). There was no different in the gender prevalence of taurodontism (Darwazeh et al., 1998, Al-Jamal et al., 2010), neither was there a difference in the prevalence of taurodontism in patients with unilateral or bilateral cleft (Al-Jamal et al., 2010). There was a prevalence of other forms of crown morphologic abnormalities in children with clefts rather than in non-cleft children (Rawashdeh and Sirdaneh, 2009).

Dilaceration: Trauma cleft lip and palate surgery could contribute to dilacerations. A prevalence of 19.2% was reported in a population of Jordanian cleft lip and palate patients with a mean age of 11.5 (5.6) years (Al-Jamal et al., 2010). The only study conducted with healthy study participants reported an insignificantly higher prevalence of dilacerations in males than in females (Hamasha et al., 2002).
Also, 18% of teeth that were dilacerations failed to emerge (Hamasha et al., 2002) (Appendix 3).

Odontomes: A case report related the cause of an unerupted primary right maxillary cuspid in a 4.5-year-old male child to the presence of a compound odontoma (Yassin and Hamori, 1999). The prevalence of odontomes reported in a retrospective study on a sample of 152 children, 5-15 years of age was 6.4% (Rajab and Hamdan, 2002). In another retrospective study of 139 patients, aged 2-16 years, odontomes were reported in 0.5% of cases; all were in the mixed dentition (Yassin and Hamori, 2009) (Appendix 2).

Gemination: A retrospective study that reviewed 1,660 dental records of patients aged 18-69 years reported a prevalence of fusion and gemination of 0.19% and 0.22%, respectively, and therefore a prevalence of 0.42% for double teeth. No significant gender differences were reported. There was a predilection for the maxillary arch and the anterior teeth. The most common teeth affected were the maxillary central incisors (3.55%) followed by mandibular third molars (0.91%) (Hamasha and Al-Khateeb, 2004) (Appendix 3).

Talon cusps: A review of 1,660 dental records of patients aged 18-69 years reported a prevalence of 2.4%; tooth level prevalence was 0.55%. No significant gender differences were reported. The most common teeth affected were the maxillary canines (46%), maxillary laterals (39%), and maxillary centrals (15%). Most (70%) cases presented unilaterally (Hamasha and Asafadi, 2010). Another prospective study on 3,660 children aged 5-12 years reported a prevalence of 0.82%. There was a male predilection: the M:F ratio was 80:20% (Fnaish et al., 2011). See Appendix 3.

Anomalies of Tooth Structure (Appendix 4)

Developmental Defects of Enamel

Enamel hypoplasia: There are very few studies on the developmental defects of enamel in Jordanians. One study on fluorosis associated the prevalence of enamel hypoplasia with residential areas but not with gender (Hamdan, 2003). The prevalence of enamel hypoplasia in cleft patients was higher in bilateral than in unilateral clefts (Al-Jamal et al., 2010).

Molar incisor hypomineralization: There are few studies on the prevalence of molar incisor hypomineralization. One study involving 3,660 children aged 5-12 years reported a prevalence of molar incisor hypomineralization of 3.28% with a male predilection (M:F, 71:41) (Fnaish et al., 2011). The only national survey on molar incisor hypomineralization recruited 3,241 students with a mean age of 8.4 (0.7) years. The prevalence was 17.6% with no gender differences. The most common teeth affected were mandibular molars (53.4%) and maxillary molars (46.6%). The maxillary incisors were more affected than the mandibular ones. The mandibular right molar was the most frequently affected tooth (22%), and the maxillary left lateral incisor was least affected (0.3%). The mean number of affected teeth per child was 2.5; 1.9 for molars and 0.6 for incisors. The study did not evaluate for the etiology of the lesion (Zawaideh et al., 2011).

Amelogenesis imperfecta: An analysis of teeth in nine families with autosomal recessive amelogenesis imperfecta (AI) was reported in a study that aimed to characterize the phenotype and to propose a molecular-based nomenclature. The teeth were studied using light and scanning electron microscopy and the amino acid of the enamel was analyzed in one case. Features reported included an affected: unaffected siblings ratio of 1:4, parental consanguinity was identified in 3 out of 9 families, and anterior open bite was present in 6 out of 9 families. The most common AI phenotype in these families was hypoplastic AI – 5 out of 9 families (Nusier et al., 2004).

Developmental defects of dentine and cementum: Studies on the developmental defects of the dentine and cementum are few. A recent case report described radicular dentine dysplasia in a 19-year-old female with Pfeiffer syndrome, and highlighted new findings of hypodontia, microdontia and dilacerations in addition to radicular dentine dysplasia in this patient (Hassona et al., 2017). Another study evaluated pre-eruptive intra-coronal resorptive dentine defects using the orthopantograms of 1,571 children with a mean age of 8.72 (2.5) years (Al-Batayneh et al., 2014). The prevalence of intra-coronal radiolucencies was 8.1%: tooth level prevalence was 0.62%. All study participants had only one affected tooth, and there were no significant gender differences in its prevalence. The most affected tooth was the mandibular first premolar (3.02%). There were more defects in the mixed dentition (89.06%) and in the mandible (79.7%) present mainly as single lesions located mesially in the crown. In 50% of the cases, the lesion extended into less than one-third of the dentine thickness. Significant predictors of its presence were the mixed dentition ($p < 0.001$) and having a decayed/filled primary predecessor – $p = 0.028$ (Al-Batayneh et al., 2014).

Gaps and Recommendation

In Jordan, the tooth emergence profile has been comprehensively investigated. There are however, limited studies on eruption anomalies. A national survey to determine the prevalence of and risk factors for developmental dental hard-tissue anomalies will be useful as most of the studies were region specific (especially in the North of Jordan/Irbid). Genetic studies are also required to determine inheritance patterns and genes involved in the Jordanian population. In view of the high prevalence of early childhood caries and high caries rates in later dentitions – and their high association with enamel hypoplasia – there is a need for studies on enamel defects in the primary and permanent dentitions. Ideally, cohort studies should be conducted to identify various anomalies and associated risk factors – genetic and environmental – in the Jordanian population.

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Appendix 1: Studies on Developmental Dental Anomalies of Tooth Number in Jordanians

Hypodontia		
Study	**Design**	**Prevalence and other findings**
Yassin and Rihani, 2006	Case Report of patients seen at the Pediatric Dental Clinic at Prince Rashid Bin AL-Hassan Hospital/Irbid (North) Age: 15 years Study participants: Male with Ehler-Danlos Syndrome	Absence of mandibular permanent incisors in panoramic x-ray
Al-Bashaireh and Khader, 2006	Cross-sectional study conducted with patients attending the teaching dental clinics at Jordan University of Science and Technology/Irbid (North) Age: 16-46 years Sample size: 1,005 (M = 521, F = 484)	Prevalence: 5.5% M:F: 5.8%/5.2% Teeth: Lower second premolars: 3.4%, Upper lateral incisors: 2.8%, Upper second premolars: 2.5% Unilateral absence of the upper lateral incisor with contralateral peg-shaped incisor (n=5); reduced crown size (n=1) and normal teeth (n=6)

Study	Design	Prevalence and other findings
Al-Jamal, Hazza'a and Rawashdeh, 2010	Review of panoramic radiographs of patients with cleft lip and palate seen at the Jordan University of Science and Technology/Irbid (North) Age: 4-31 years Mean: 11.5 (5.6) years Sample size: 78 (M = 42, F = 36) 30 with bilateral cleft lip and palate and 48 with unilateral cleft lip and palate	Prevalence: 66.7% (n= 52) Gender: No significant differences Teeth: Maxillary lateral incisor Maxillary second premolar Mandibular second premolar
Fnaish et al., 2011	Prospective study conducted in December 2004 at Prince Rashid Bin AL-Hassan Hospital/Irbid (North) Age: 5-12 years Sample size: 3,660 (M = 1,920, F = 1,740) Non-syndromic	Prevalence: 8.83% M/F: 39%:61% The most prevalent dental anomaly (52.86%). Other anomalies were supernumerary, molar incisor hypomineralisation and talon cusp The most common missing teeth not reported

Study	Design	Prevalence and other findings
Abdallah et al., 2015	A review of dental records between 2011 and 2014 at the University of Jordan in Amman Age: 8.6 to 25.4 years Mean: 17.3 (4.7) years Sample size: 3,315 Agenesis diagnosed in both arches were excluded	Prevalence: 6.5% M/F: 39.2%/60.8% Teeth: Maxillary lateral incisors (87.7%) Maxillary second premolars (10.4%) Mandibular second premolars (64.3%) Mandibular central incisors (38.6%) Associated anomalies: Microdontia of maxillary lateral incisor (46.7%) Retained mandibular primary molars (60.0%) Impacted mandibular teeth (38.6%); Infraoccluded mandibular primary molar (7.1%) Similar prevalence in both arches: transposition, supernumerary teeth and ectopic eruption of permanent molars The causes of hypodontia and association with other anomalies were not mentioned

Supernumerary Teeth		
Study	**Design**	**Prevalence and other findings**
Hattab, Yassin and Rawashdeh, 1994	Case reports Number of cases: 3: Case (1) = 9 M Case (2) = 6 M Case (3) = 8 M	Case (1): 2 supernumerary (conical and supplemental) Case (2): 2 supernumerary (tuberculate) Case (3): 2 supernumerary teeth
Rajab and Hamdan, 2002	Retrospective study of patients seen at the University of Jordan in Amman between 1996 and 2002. Age: 5-15 years Mean: 101 (1.9) years Sample size: 152 (M = 105, F = 47)	Prevalence: not reported M:F: 148:54 One supernumerary: 77% Two supernumerary: 18·4% Three or more supernumerary: 4·6% Conical shape: 74.8% Tuberculate shape: 11.9% Supplemental: 6.9% Odontoma: 6.4% Located in premaxilla: 89·6% Located centrally: 92·8% Located in midline: 25% Located in premolar region: 6·5%

Study	Design	Prevalence and other findings
		Located in canine region: 2·5% Located in mandibular central area: 1% Located in maxillary molar area: 0·5% Normal orientation: 83.1% Inverted: 10.1% Transverse: 6.8%
Yassin and Hamori, 2009	Retrospective study of record of patients seen between April 1993 and June 2007 at Prince Rashid Bin AL-Hassan Hospital/Irbid (North) Age: 2-16 years Mean: 9.43 years Sample size: 139 patients	Prevalence: Not available 186 supernumeraries identified in 139 patients M:F: 2.2:1 Conical shape: 65.0% Conical in primary dentition: 8.1% Conical in permanent dentition: 15.1% Conical in mixed dentition: 1.9% Supplemental: 23.7% Supplemental in primary dentition: 7.5% Supplemental in permanent dentition: 3.2% Supplemental in mixed dentition: 12.9% Tuberculate shape: 10.8% Tuberculate in primary dentition: 0%

Study	Design	Prevalence and other findings
		Tuberculate in permanent dentition: 1.6% Tuberculate in mixed dentition: 9.1% Odontoma: 0.5% Odontoma in primary dentition: 0% Odontoma in permanent dentition: 0% Odontoma in mixed dentition: 0.5% One supernumerary: 78.3% Two supernumeraries: 18.7% Three or more supernumeraries: 2.9% Located in the premaxilla: 88.1% Located in the upper premolar, canine, lower central incisor and lower premolar areas: 11.9% Associated anomalies seen in 10 (7.2%) of patients

Study	Design	Prevalence and other findings
Al-Jamal, Hazza'a and Rawashdeh, 2010	Review of panoramic radiographs of patients with cleft lip and palate seen at the Jordan University of Science and Technology/Irbid (North) Age: 4-31 years Mean: 11.5 (5.6) years Sample size: 78 (M = 42, F = 36) 30 with bilateral cleft lip and palate and 48 with unilateral cleft lip and palate	Prevalence: 16.7% M:F: not statistically significant No significant association between cleft type and supernumerary
Fnaish et al., 2011	Prospective study conducted in December 2004 at Prince Rashid Bin AL-Hassan Hospital/Irbid (North) Age: 5-12 years Sample size: 3,660 (M = 1,920, F = 1,740) Non-syndromic	Prevalence: reported as 3.77% in tables vs. 4.5% in text M:F: 65%/35% Second most prevalent anomaly (22.59%) after hypodontia Types of supernumerary teeth were not mentioned

Appendix 2: Studies on Developmental Dental Anomalies of Tooth Size in Jordanians

Microdontia		
Study	**Design**	**Prevalence and other findings**
Al-Bashaireh and Khader, 2006	Cross-sectional study conducted with patients attending the teaching dental clinics at Jordan University of Science and Technology/Irbid (North) Age: 16-46 years Sample size:1,005 (M = 521, F = 484)	Prevalence: 2.9% of lateral incisors had reduced crown size by less than 5.5 mm M/F: 18/23 .
Al-Jamal, Hazza'a and Rawashdeh, 2010	Retrospective study of panoramic radiographs of cleft lip and palate patients at Jordan University of Science and Technology/Department of oral medicine and surgery/Irbid (North) Age: 4-31 years Mean: 11.5 (5.6) years Sample size: 78 (M = 42, F = 36) 30 with bilateral cleft lip and palate and 48 with unilateral cleft lip and palate	Prevalence: 37% M/F: 24.4%/12.8% The most commonly missing teeth were maxillary lateral incisors, followed by maxillary or mandibular second premolars and, to a lesser extent, maxillary central incisors

Tooth size discrepancy		
Study	**Design**	**Prevalence and other findings**
Hattab, Al-Khateeb and Sultan, 1996	Cross-sectional study on permanent teeth conducted at the Dental clinics of Jordan University of Science and Technology/Irbid (North) Mean age: M = 15.7 (±2.6) years F = 15.1 (±2.2) years Sample size: 198 patients (M = 86, F = 112)	Males had significantly larger teeth than females Canines displayed greater sexual dimorphism in crown size than any other tooth class The cumulative tooth widths of males were significantly different from those of females by a sum of 3.1 mm in the maxilla, and 3.6 mm in the mandible No significant differences in the width of teeth on left and right sides of the dental arch Teeth: Variability in mesio-distal diameter: Maxillary lateral incisors (8.8%) Mandibular lateral incisors (7.3%) All first molars (5.8%)
Al-Khateeb and Abu Alhaija, 2006	Cross-sectional study Age: 13-15 years	Females had smaller teeth than males Class III malocclusion showed larger teeth than other occlusal categories

Study	Design	Prevalence and other findings
	Sample size: 140 study models	Class II division 1 showed the narrowest maxillary arch compared with other types of malocclusion
Al-Omari, Al-Bitar, and Hamdan, 2008	Cross-sectional study with participants recruited from 12 schools in 6 different regions in Amman, Jordan Mean age: 15.5 years Sample size: 367 study models (F = 193, M = 174)	Significant gender differences in the mesiodistal width of teeth except for the mandibular right central incisor, maxillary right and left second premolars, and maxillary right and left lateral incisors No statistically significant differences in the mesiodistal width of teeth of males and females for the anterior and overall ratios Tooth size discrepancy ratios were larger for males though gender differences were not significant No significant differences in measurements of contralateral teeth except for mandibular first molars, maxillary and mandibular second premolars and maxillary lateral incisors Anterior teeth size discrepancies: 92.2% Overall tooth size discrepancies: 78.6%

Study	Design	Prevalence and other findings
Shaweesh, 2017	Cross-sectional study conducted at the Dental Teaching Centre of Jordan University of Science and Technology/Irbid (North) between 2005 and 2015 Age: 11-18 years Mean: M = 15.4 years; F = 14.8 years Sample size: 204 dental casts (M = 80, F = 124)	Males had larger teeth than females. Significant gender difference in the mesiodistal dimension. Difference less significant for the faciolingual dimension

Appendix 3: Studies on Developmental Dental Anomalies of Tooth Shape in Jordanians

Taurodontism		
Study	**Design**	**Prevalence and other findings**
Darwazeh, Hamasha and Pillali, 1998	Retrospective study of dental records at Jordan University of Science and Technology/Irbid (North) Age: 18-78 years Mean: 25.6 years Sample size: 875 dental records (M = 517, F = 358)	Prevalence: 8% Patients with more than one tooth affected: 4.4% M:F: 7.9%:8.1% (P >0.05) Maxilla: 61.2% Mandible: 38.8% The most affected teeth were the maxillary second molar followed by the maxillary and mandibular first molar 26.7% of taurodonts had pulp calcifications or stone
Al-Jamal, Hazza'a and Rawashdeh, 2010	Retrospective study of panoramic radiographs of cleft lip and palate patients at Jordan University of Science and Technology/Department of oral medicine and surgery/Irbid (North) Age: 4-31 years Mean: 11.5 (5.6) years	Prevalence: 70.5% No significant gender difference No significant correlation with type of cleft

Taurodontism		
Study	**Design**	**Prevalence and other findings**
	Sample size: 78 (M = 42, F = 36) 30 with bilateral cleft lip and palate and 48 with unilateral cleft lip and palate	
Peg-shaped lateral incisors		
Study	**Design**	**Prevalence and other findings**
Al-Bashaireh and Khader, 2006	Cross-sectional study conducted with patients attending the teaching dental clinics at Jordan University of Science and Technology/Irbid (North) Age: 16-46 years Sample size: 1,005 (M = 521, F = 484)	Prevalence: 2.3% No gender difference No difference between right and left sides
Dens invaginatus		
Study	**Design**	**Prevalence and other findings**
Hamasha and Al-Omari, 2004	Retrospective study of dental records of patients conducted at the Faculty of Dentistry, Jordan University of Science and Technology/Irbid (North)	Tooth level prevalence: 0.65% Age was not discussed M:F: 64%:36% (P >0.05) Maxillary lateral incisor: 8.7% Prevalence: 2.95% Maxillary canine: 0.5%

Dens invaginatus		
Study	**Design**	**Prevalence and other findings**
	Sample size: 1,660 dental records, 3,024 periapical X- rays, 9,377 teeth (maxillary = 4,713, mandibular = 4,664) M = 5,633, F = 3,744	Maxillary first premolar: 0.4% Maxillary third molar: 0.3% Unilateral lesions: 75.5% Bilateral lesions: 24.5%
Crown morphology abnormalities		
Study	**Design**	**Prevalence and other findings**
Rawashdeh and Abu Sirdaneh, 2009	Prospective study of patients with cleft lip and palate attending the King Abdullah University Hospital Irbid (North) between November 2003 and September 2005. Mean age: patients with cleft lip and palate – 13.4 years Mean age: patients without cleft lip and palate – 14.6 years Sample size: 100 patients with cleft lip and palate and 60 patients without cleft lip and palate Unilateral cleft lip and palate (M = 33, F = 35)	Prevalence: 13.3% Patients with cleft lip and palate: 13.3% Patients without cleft lip and palate: 2% Control group: 2%, teeth, Mean 0.33 Maxillary lateral incisors: 37.7% Mandibular central incisor: 25% Cleft lip and palate vs. control Peg-shaped teeth (incisors and canines): 46.3% vs. 8.5% Missing hypocone (1^{st} molar): 10.8% vs. 0% Excess mamelons (central and lateral incisors): 36.3% vs. 2.1% Malformed premolars: 6.8% vs. 2.4% T-shaped lateral incisors: 1.9% vs. 0%

Study	Design	Prevalence and other findings
	Bilateral cleft lip and palate (M = 17, F = 15) Patients without cleft lip and palate (M = 26, F = 34)	Incisor fissure (central and lateral incisors): 1.3% vs. 0% Fused hypocone (1^{st} molars): 2.5% vs. 0%
Enamel pearls		
Study	**Design**	**Prevalence and other findings**
Darwazeh and Hamasha, 2000	Retrospective study of dental records of patients at the Faculty of Dentistry, Jordan University of Science and Technology/Irbid (North) Sample size: 819 (M = 499, F = 320) dental records 1,032 periapical x-rays and 2,896 permanent teeth (2,064 molars)	Prevalence: 4.5% Tooth level prevalence: 2.32% M:F: 5.2%:3.4% (P >0.05) Maxillary molars: 39.6% Mandibular molars: 60.4% 1 affected molar: 83.8% 2 affected molars: 10.8% 3 affected molars: 2.7% 5 affected molars: 2.7% First molars: 56% More common in the mandibular first molar and maxillary first molars. Third molars least affected.

Dilaceration		
Study	**Design**	**Prevalence and facts**
Hamasha, Al-Khateeb and Darwazeh, 2002	Retrospective study of dental records of patients at the Faculty of Dentistry, Jordan University of Science and Technology/Irbid (North) Age: 18- 69 years Mean: 25.1 years Sample size: 814 dental records, 1,586 periapical x-rays, 4,655 teeth (M = 2,797, F = 1,858)	Prevalence: 17% Tooth level prevalence: 3.8% M:F: 58%:42% (P >0.05) Mandibular 3rd molars: 19.2% Mandibular 1st molars: 5.6% Maxillary 2nd premolars: 4.7% Mandibular 2nd molars: 3.6% Anterior teeth: 1% Unerupted dilacerations: 18% Erupted dilacerations: 82%
Al-Jamal, Hazza'a and Rawashdeh, 2010	Retrospective study of panoramic radiographs of cleft lip and palate patients at Jordan University of Science and Technology/Department of oral medicine and surgery/Irbid (North) Age: 4-31 years Mean: 11.5 (5.6) years	Prevalence: 19.2% M:F:11.5%:7.7% (P >0.05) Unilateral cleft lip and palate: bilateral cleft lip and palate: 14.1%:5.1% (P <0.05)

Study	Design	Prevalence and other findings
	Sample size: 78 (M = 42, F = 36) 30 with bilateral cleft lip and palate and 48 with unilateral cleft lip and palate	
Gemination and Fusion (double tooth)		
Study	**Design**	**Prevalence and other findings**
Hamasha and Al-Khateeb, 2004	Retrospective study of dental records of patients conducted at the Faculty of Dentistry, Jordan University of Science and Technology/Irbid (North) Sample size: 1,660 dental records, 3,024 periapical X- rays, 9,377 teeth (maxillary = 4,713, mandibular = 4,664) M = 5,633, F = 3,744	Prevalence: Fusion 0.19%, gemination 0.22%, total 0.42% No significant gender difference Maxillary central incisors most affected: 3.55% Mandibular third molars least affected: 0.91% Anterior region: 71.8% Maxillary arch: 74.4% Mandibular arch: 25.6%

Talon Cusp		
Study	**Design**	**Prevalence and other findings**
Hattab, Yassin and Al-Nimri, 1995	Case report of a patient at Dental Center Jordan University of Science and Technology/Amman (Middle) Case (1): Age: 11 years, M Case (2): Age: 35 years, F Case (3): Age: 11 years, F Case (4): Age: 23 years, F	**Case (1):** Talon cusp on maxillary left lateral incisor associated with shovel- shaped contralateral maxillary lateral incisor, exaggerated Carabelli cusp on the primary maxillary right second molar; additional tubercle on the palatal surface of the maxillary right central incisor **Case (2):** Talon cusp on maxillary left premolar associated with microdont maxillary right premolar with dens invaginatus and shovel-shaped central incisors with tubercle-like cingula **Case (3):** Talon cusp on maxillary left lateral incisor associated with shovel-shaped maxillary right lateral incisor with dens invaginatus **Case (4):** Talon cusp on maxillary left lateral incisor and maxillary canines associated with accentuated bifid cingulum on shovel-shaped maxillary right lateral incisor
Hattab and Yassin, 1996	Case report of a 17-month-old male	Bilateral talon cusp on maxillary primary central incisors with a supplemental maxillary left lateral incisor. The talon cusps were causing tongue irritation and occlusal interference

Study	Design	Prevalence and other findings
Hattab, Yassin and Al-Nimri, 1996	Case reports Case (1): Age: 17 years, M Case (2): Age: 9 years, F Case (3): Age: 16 years, M Case (4): Age: 9 years, M Case (5): Age: 12 years, F Case (6): Age: 11 years, F Case (7): Age: 18 years, M	**Case (1):** Talon cusp on maxillary right lateral incisor, associated with a shallow groove on the labial enamel surface of the tooth extending from incisal edge to the cervical third of crown. **Case (2):** Talon cusp on maxillary right lateral incisor, associated with a shallow groove running vertically over the entire labial surface of the tooth, accentuated palatal cusps on maxillary primary canines and agenesis of maxillary permanent left canine **Case (3):** Talon cusp on maxillary left lateral incisor associated with shovel-shaped maxillary right lateral incisor with type 1dens invaginatus, and accessory cusps on palatal surface of maxillary right second premolar and first molars **Case (4):** Talon cusp on maxillary left lateral incisor associated with shovel-shaped central incisors, bifid cingulum of left central incisor and tubercle-like cingulum on right central incisor **Case (5):** Talon cusp on maxillary left lateral incisor associated with accentuated marginal ridge on maxillary right lateral incisor, large cusps of Carabelli on maxillary first molars

Study	Design	Prevalence and other findings
		Case (6): Talon cusp maxillary right lateral incisor, in the same arch it was associated with shovel-shaped central incisors, bifid cingulum on maxillary right central incisor and tubercle-like cingulum maxillary left central incisor **Case (7):** Four small prominent cusps on palatal surface of maxillary lateral incisors and maxillary canines respectively associated with shovel-shaped maxillary right central incisor, bifid cingulum on maxillary right incisor, additional tubercle on maxillary left central incisor and exaggerated cusps of Carabelli on maxillary first molar
Al-Omari, Hattab and Darwazeh, 1999	Case reports from the Jordan University of Science and Technology/Amman (Middle) Case (1): Age: 16 years, F Case (2): Age: 8 years, F	**Case (1):** Maxillary left supernumerary tooth associated with a shallow vertical groove on the labial surface of taloned tooth, shovel-shaped maxillary lateral incisor, exaggerated bifid cingulum and marginal ridges on maxillary canines, palatally erupted mesiodens and bilateral unerupted maxillary supernumerary teeth **Case (2):** Talon cusp on maxillary right central incisor associated with accentuated bifid cingulum on shovel-shaped maxillary right lateral incisor
Hattab and Hazza'a, 2001	Case report: 9 years, M	Talon cusp on maxillary left central incisor with large and bifid crown with talon cusp

Study	Design	Prevalence and other findings
Hamasha and Asafadi, 2010	Retrospective study of records of patients seen at Jordan University of Science and Technology/Irbid (North) Age: 18- 69 years Mean: 25.1 years Sample size: 1, 660 records, 3,024 Periapical radiographs and 9,377 teeth (M = 5,633, F = 3,744) Maxillary teeth: 4,713 Mandibular teeth 4,664	Prevalence: 2.4% Tooth level prevalence: 0.55% M:F: 57%:53% (P >0.05) Talon cusp on maxillary canines: 46% Talon cusp on maxillary lateral: 39% Talon cusp on maxillary central: 15% Bilateral presentation of talon cusp: 30% Unilateral presentation of talon cusp:70%
Fnaish et al., 2011	Prospective study conducted in December 2004 at Prince Rashid Bin AL-Hassan Hospital/Irbid (North) Age: 5-12 years Sample size: 3,660 (M = 1,920, F = 1,740) Non-syndromic	Prevalence: 0.82% M:F: 80%:20% Teeth with talon cusps were not mentioned

Appendix 4: Studies on Developmental Dental Anomalies of Tooth Structure in Jordan

Fluorosis		
Study	**Design**	**Prevalence and facts**
Hamdan, 2003	Cross-sectional national study covering Amman, Zarqa, Irbid, Mafraq, Balqa, Karak, Tafila and Ma'an regions **Age**: 12 years Sample: 1,878 children recruited from urban and rural areas	Maxillary central incisors: 18·5% Maxillary lateral incisors: 13·6% Mandibular central incisors: 11.3% Mandibular lateral incisors: 9·9% No significant gender difference observed except in Tafila, where more females were affected Greater prevalence in rural than in urban areas except in Zarqa, Irbid, and Mafraq Fluorosis score: Score 1: 18·5% Score 2: 16·5% Score 3: 11% Score 4: 9% Score 5: 4·2% Direct relationship between fluoride level in drinking water and prevalence of fluorosis

Enamel Hypoplasia

Study	Design	Prevalence and other findings
Al-Jamal, Hazza'a and Rawashdeh, 2010	Retrospective study of panoramic radiographs of cleft lip and palate patients at Jordan University of Science and Technology/Department of oral medicine and surgery/Irbid (North) Age: 4-31 years Mean: 11.5 (5.6) years Sample size: 78 (M = 42, F = 36) 30 with bilateral cleft lip and palate and 48 with unilateral cleft lip and palate	Prevalence: 30.8% No statistically significant gender difference Bilateral cleft lip and palate: 24.4% Unilateral cleft lip and palate: 6.4%

Molar-Incisor Hypomineralization

Study	Design	Prevalence and other findings
Fnaish et al., 2011	Prospective study conducted in December 2004 at Prince Rashid Bin Al-Hassan Hospital/Irbid (North) Age: 5-12 years Sample size: 3,660 (M = 1,920, F = 1,740) Non-syndromic	Prevalence: 3.28% M:F: 59%:41%

Study	Design	Prevalence and other findings
Zawaideh, Al-Jundi and Al-Jaljoli, 2011	Cross-sectional national study conducted in north, middle and south Jordan from March to June, 2009 Sample size: 3,241 students (M = 1,702, F = 1,539) Mean age: 8.4 (0.7)	Prevalence: 17.6% M:F: 17.4%:17% (P >0.05) Mandibular molars: 53.4% Maxillary molars: 46.6% Mandibular right molar: 22% Maxillary left lateral incisor: 0.3% Mandibular molars > Maxillary molars (P <0.05) Maxillary incisors > mandibular incisors (P <0.05) Severity (Wetzel and Reckel Scale) Mild: 44% Moderate: 14% Severe: 42%

Amelogensis Imperfecta		
Study	**Design**	**Prevalence and other findings**
Nusier et al., 2004	Case series on 9 families with autosomal recessive amelogenesis imperfecta Teeth examined clinically and radiographically. Exfoliated and extracted teeth examined with light and scanning electron microscopy. Enamel assessed using amino acid analysis	Diverse phenotypes including localized hypoplastic, generalized thin hypoplastic, hypocalcified and hypomaturation types Most common amelogenesis imperfecta phenotype – hypoplastic: 5 in 9 families Affected: unaffected siblings: 1:4 Parental consanguinity identified in 3 of 9 families
Dentin Dysplasia		
Study	**Design**	**Prevalence and other findings**
Hassona et al., 2017	Case report of a 19-year-old female with Pfeiffer syndrome	Dental anomalies: Hypodontia Microdontia Dilacerations Radicular dentine dysplasia

Kenya

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Background Information on Kenya

Kenya is a country on the eastern side of Africa. Its southeastern region borders the Indian Ocean, and Somalia borders its eastern side. The remaining borders are shown in Figure 1. The equator passes through the central part of Kenya, making it a country that enjoys mainly a tropical climate, save for the highlands, where temperatures can vary depending on the season of the year.

Kenya has 44 recognized indigenous tribes, of which 13 constitute most of the Kenyan population (National Population and Housing Census, 2009). The tribes have unique languages, in addition to the Swahili and English languages, which are the country's national and official language, respectively. Kenya permits freedom of religion, with half of the population being Christian, 10% Muslim, and the remainder Hindu, Sikh, traditionalists, animists and others (National Population and Housing Census, 2009). Members of many tribes interweave native beliefs with traditional religion.

Of the Kenyan population, 42.9% are children below 14 years of age. An estimated 29% and 46% of children were living with human immunodeficiency virus (HIV) in 2014 and 2016, respectively (National AIDS Control Council, 2016). HIV infection is linked to increased risk for developmental dental hard-tissue anomalies (Kemoli et al., 2015). The same effects are likely to occur following other common febrile illnesses

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Figure 1. Map of Kenya showing its borders with other Eastern African countries and the Indian Ocean

common in Kenyan children, such as malaria, upper respiratory tract infections, urinary tract infections, and some other viral infections, that also cause significant morbidity and mortality for children under the age of 5 years (Prasad et al., 2015). If these diseases occur during the period of amelogenesis, then the chances are that defects will be noted in the enamel. The Kenya Demographic and Health Survey (KDHS, 2014) revealed that the under-five mortality rate is 52 deaths per 1000 live births, mainly caused by acute respiratory infection, diarrhea, measles, malaria, and malnutrition (KDHS, 2014).

Many areas of Kenya have water sources with high amounts of fluoride. These include Nairobi, the Rift Valley, the eastern and central provinces, and parts of Nyanza. These areas correspond to geographic locations of volcanic activity and the Rift Valley region. Water from most of the boreholes in these areas has fluoride ion concentrations above 1.0 ppm, and 19.5% contain water with over 5.0 ppm (Nair et al., 1984). Dental fluorosis is, therefore, common in children resident in these areas.

Further, the National oral health survey (National Population and Housing Census, 2009) showed that 24% of the children presented with a complaint of fever, a condition that leads to metabolic stress, which can interfere with the secretion of the enamel matrix during tooth development. Such disruptions can result in the formation of linear enamel hypoplasia that corresponds to the time when that part of the tooth was forming.

Most Kenyans are in the low socioeconomic strata and often practice traditional beliefs and traditional medicine (Abdullahi, 2011). Their low socioeconomic status implies that they seek cheaper and readily accessible alternative medical care. Some traditional beliefs associate common childhood illnesses, such as diarrhea and fever, with tooth eruption, and parents resort to traditional remedies to prevent and treat these childhood concerns (de Zoysa et al., 1984). One of these remedies is infant oral mutilation, a traumatic procedure that is intended to relieve pain and discomfort during tooth eruption. It involves incising the gingiva with a lancet to help a tooth erupt (Ashley, 2001). In 1575, Ambriose Pare, a French army surgeon, used it to relieve “breeding tooth.” In 1668, Francois Mauriceau conducted similar procedures. In 1742, Joseph Hurlock encouraged the use of this practice to prevent childhood deaths caused by teething (Kowitz, 1993).

Timing and Sequence of Emergence of Permanent Dentition

Hassanali and Odhiambo (1981) studied patterns of emergence of the permanent teeth in Kenyan children of African and Asian descent. As illustrated in Table 1, females generally had their teeth erupting earlier than males in both races. Except for the premolars, mandibular teeth erupted earlier than maxillary teeth in both races. Maxillary premolars emerged 0.1-0.2 years earlier than mandibular premolars in both races. In general, permanent teeth, especially the mandibular teeth, emerged earlier in African descendants than in Asian descendants.

Table 1. The mean eruption ages in years for Kenyan children of African and Asian descent

Tooth Type	African children		Asian children	
	Females (yrs)	**Males** (yrs)	**Females** (yrs)	**Males** (yrs)
Mandibular teeth				
First molar	5.70	6.03	6.08	6.47
Central incisor	5.62	5.83	6.34	6.57
Lateral incisor	6.56	6.86	7.19	7.52
Canine	9.20	9.96	9.66	10.58
First premolar	9.62	10.05	9.84	10.58
Second premolar	10.23	10.90	10.66	11.37
Second molar	11.07	11.39	11.13	11.90
Maxillary teeth				
First molar	6.13	6.32	6.27	6.67
Central incisor	6.55	6.91	6.95	7.24
Lateral incisor	7.71	7.99	7.97	8.36
Canine	10.26	10.93	10.60	11.24
First premolar	9.40	9.87	9.74	9.97
Second premolar	10.15	10.74	10.69	11.10
Second molar	11.40	11.54	11.54	12.20

There was considerable variation in the order in which permanent teeth emerged in the oral cavity. The sequence of permanent teeth emergence in Kenyan children of African and Asian descent is summarized in Table 2. The mandibular central incisors emerged earlier than the mandibular first molars in children of Asian descent rather than in children of African descent (Hassanali and Odhiambo, 1981).

Table 2. Sequence of emergence of permanent teeth in Kenyan children of African and Asian descent

	African children	**Asian children**
Maxillary teeth	M_1, I_1, I_2, PM_1, PM_2, C, M_2	M_1, I_1, I_2, PM_1, PM_2, C, M_2
Mandibular teeth	I_1, M_1, I_2, C, PM_1, PM_2, M_2	M_1, I_1, I_2, C, PM_1, PM_2, M_2

The time of emergence of the third molar was earlier in African descendants than in Asian descendants (Hassanali, 1985). The mandibular third molar emerged by 17.6-18.3 years in Kenyan Africans, whereas it emerged at 19.9-20.3 years in Kenyan Asians. Similarly, the maxillary third molar emerged at 18.5-18.9 years for Kenyan Africans, whereas it emerged at 20.7-21.0 years for Kenyan Asians. The emergence of the third molar started by 13 years of age in Kenyan Africans; by 18.5 years of age, all four molars were present in 50% of adolescents. In Kenyan Asians, the emergence of the third molar started at 15 years of age; by 21.5 years of age, 50% had all four molars present.

Some intra-group differences (Kenyan Africans versus Kenyan Asians) were observed. While Kenyan African female children completed the emergence of their permanent teeth earlier than males by 0.3-0.4 years, similarly, Kenyan Asian females completed theirs later than males by 0.3 years.

Timing and Sequence of Emergence of Primary Dentition

There is no known study on the timing and sequence of emergence of the primary dentition for children in Kenya.

Delayed Tooth Eruption

Several diseases can cause delayed or ectopic eruption of teeth. These include Burkitt's lymphoma, lymphoma, and noma. Although these diseases are prevalent in Kenya (Mwanda, 2005), there is no information about their impact on tooth eruption or tooth emergence in Kenyan children.

Developmental Dental Hard-tissue Anomalies

Anomalies of tooth number: Tooth number can be due to agenesis, hypodontia or hyperdontia, as a result of genetic problems, environmental factors, chemotherapy, radiotherapy, trauma, drugs, and infection. In the case of agenesis, the most commonly affected teeth are the third molar, the second premolar, and the lateral incisors. There are no studies of the prevalence of agenesis, hypodontia, or hyperdontia in Kenya.

Anomalies of tooth size: Tooth size can be affected by many genetic and environmental factors. No studies have reported on the prevalence or causes of variations in tooth size or shape in Kenya. However, Kemoli and Sheikh (2017) reported the case of a 17-year-old Kenyan girl with a mesially rotated lower right permanent canine, a dilacerated mesial root with an enlarged pulp chamber and root canal, and radiculomegaly of the tooth with a crown-to-root-ratio of more than 1:4. Also, the upper permanent canines had increased root length, and the lower second premolars were missing. These variations were reported as a case of non-syndromic radiculomegaly of the lower right permanent canine (Kemoli et al., 2017).

Anomalies of tooth shape: There are no known studies of tooth-shape anomalies conducted in Kenya.

Anomalies of tooth structure: Dental oral mutilation often results in enamel defects, loss of teeth, and reduced arch size. Partial extraction of the permanent cuspids, lying below the targeted primary cuspid, often results in hypoplasia, displacement, and impaction of the permanent cuspid. If the dental lamina of the developing tooth is not removed during the mutilation, it may continue to develop, although damaged, resulting in a dysplastic or mal-developed tooth or odontoma (Hassanali and Amwayi, 1993). The case of a small odontoma at the site of a mandibular canine extracted early in childhood by a traditional healer has been reported (Erlandsson and Bäckman, 1999).

Molar incisor hypomineralization: There are indications that molar incisor hypomineralization may be a significant problem in Kenyan children. Kemoli (2008) screened 3,591 children aged 6-8 years and reported a prevalence of 13.7%, with a female to male ratio of 3:1. Molar incisor hypomineralization was associated with childhood diseases and malnutrition. It was also associated with HIV infection –perhaps due to direct viral effects or antiretroviral medications. Two cases of HIV-positive children with the lesion have been reported (Kemoli et al., 2015).

Fluorosis: The prevalence and severity of dental fluorosis in children in Nairobi were assessed with the Thylstrup and Fejerskov Index: 18% of the 6-8-year-olds examined had dental fluorosis in their primary dentition, and 76% of 13-15-year-olds had fluorosis in their permanent dentition (Ng'ang'a and Valderhaug, 1993).

River water was the source of drinking water for most children. The amount of fluoride in the river water varies from season to season: higher concentrations are found during the dry spells when compared to the rainy periods. The amount of fluoride in the river at the time of collection of the samples was estimated to be 0.2-0.4 ppm, and children who consumed borehole water had Thylstrup and Fejerskov Index scores $\geq$5. Dental fluorosis causes esthetic problems, tooth sensitivity due to the chipping of enamel, plaque retention on tooth surfaces, and a predisposition to gingivitis and dental caries. Other sources of fluoride are dietary, such as milk and vegetables, grown in high fluoride soils (Williamson, 1953; Gitonga and Nair, 1982; Opinya et al., 1989; Ng'ang'a and Valderhaug, 1993; Kahama et al., 1997).

Infant oral mutilation: This is the gouging of primary canine tooth buds to prevent or treat teething problems. The canine tooth buds are gouged, using sharp objects, such as hot nails, sharpened bicycle spokes, or knives pressed into a child's gums (Hassanali et al., 1995). It has been practiced by the Maasai tribe members since the 1960s, who probably learned it from other tribes in Uganda and Tanzania (Pindborg, 1969). The prevalence of infant oral mutilation is 87% in Kenyan Maasai children (Hassanali et al., 1995), and it is practiced by many other tribes in Kenya. The procedure is performed at around the ages of one month to 2-3 years, with a peak age between 4 and 18 months. Dental hard-tissue anomalies that arise from this practice include impacted canines, delayed eruption, and dilaceration of the permanent canines (Hassanali et al., 1995).

Gaps and Recommendations

Heath Information, Training, and Access to Modern Medical Facilities

Despite the abolition of the 1910 Medical Practitioners and Dentists Ordinance of Kenya (Medical Practitioners and Dentists Ordinances, 27th September, 1910), which delineated western medicine and traditional practices, this ordinance still shapes the government's engagement with traditional healers. Many Kenyans still resort to traditional health practitioners for the management of oral health problems, and hence the practice of infant oral mutilation continues to persist. The public education and training of traditional health practitioners may help to reduce this problem, as will increased access, availability and affordability to modern health care services.

Defluoridation Factor

Many areas in Kenya have high amounts of fluoride in soil, water, and certain plants. In these areas, many people, including children, depend on rivers, boreholes, and wells for their drinking water. Thus, children from these areas develop dental fluorosis. Except for one area in the Rift Valley, where there is a defluoridation plant, other areas in Kenya with elevated fluoride levels in water sources do not have such facilities. To save children from dental fluorosis, the Kenyan Government should support defluoridation research and accessibility.

Research on Developmental Dental Hard-tissue Anomalies

There are gaps in knowledge about the timing and sequence of emergence of the primary dentition in Kenyans. Also, little is known about many developmental dental hard-tissue anomalies. Efforts should be made to close these information gaps so that the oral health of Kenyans can be improved.

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LIBYA

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Background Information on Libya

Libya is on the Mediterranean coast of North Africa, between Egypt and Sudan on the east, Tunisia and Algeria on the west, and Chad and Niger on the south. Libya extends over 1,760,000 km, making it the seventh largest country in the world and the fourth largest country in Africa. Despite its large area, Libya has a population of just above 6 million, most of whom live in the coastal cities of Tripoli, the capital, and Benghazi, the second largest city. The Libyan population is relatively young, with a mean age of 28.5 years, and the gender distribution is almost equal. Children younger than 15 years of age constitute 26% of the Libyan population (The World Factbook, 2017). Figure 1 is a representation of the map of Libya and the age distribution of the Libyan population.

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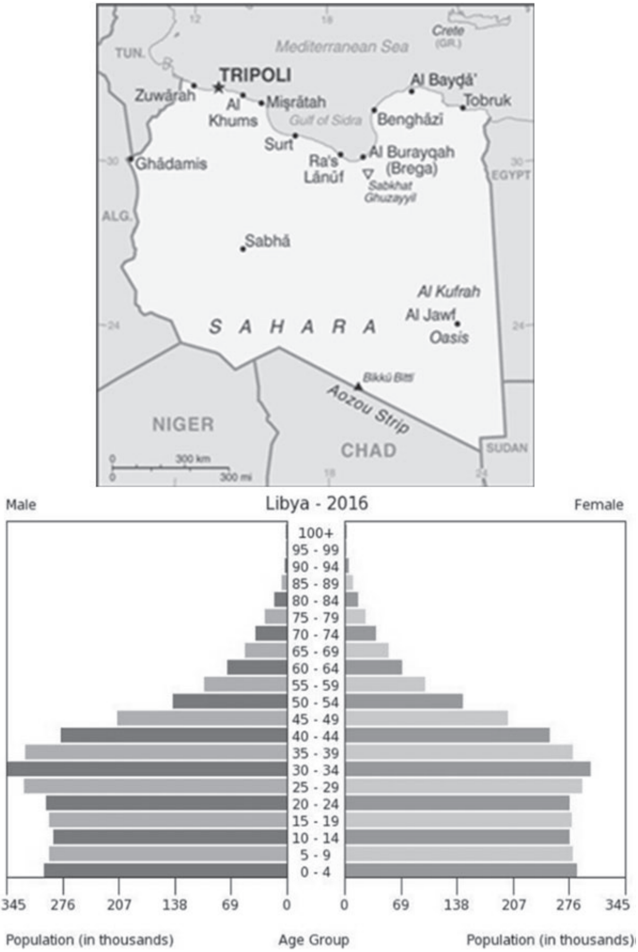

Figure 1: the map of Libya and the age distribution of the Libyan population

Since the uprising in February 2011, the country has become a hotspot for political and internal armed conflicts. Libya now has three governments, none of which is a legitimate government with the authority to address the basic needs of the Libyan population. The country faces much instability arising from multiple armed conflicts. Consequently, oil exports have markedly decreased (Ali and Harvie, 2013), depriving the country of its main source of income (The World Factbook, 2017). Benghazi city has been worst hit by the economic difficulties and armed conflict, being the center of urban warfare since June 2014. Internal displacement, poor social services, stress, financial hardship and limited resources have affected people's health, including dental health. For example, an exploratory study of the impact of the Libyan conflict on sugar consumption found a decreased sugar intake compared with that before the conflict (Aheiam, 2016). Luckily, the crisis did not affect the sources of public water, which are optimally fluoridated – 0.8 ppm (Huew, 2010).

Timing and Sequence of Emergence of Primary and Permanent Dentitions

Only one study has reported on the of emergence of permanent teeth in Libyan children (Ommar, 1994). The study found that the sequence of eruption of permanent teeth was similar for all children, irrespective of gender and area of residence. The eruption time was earlier in females than in males and in rural children than in urban children. The sequence of eruption is like that observed in other countries. The sequence of eruption of permanent teeth for Libyan children was:

Maxilla: M1, I1, I2, P1, P2, C, M2
Mandible: M1, I1, I2, C, P1, P2, M2

Developmental Hard Dental-tissue Anomalies

Imam Abdelgader (2015) reviewed the records of 252 orthodontic patients – 57 males and 195 females – and found a prevalence of dental anomalies of 54%. Anomalies were more numerous in females. The most common anomalies were ectopic erupted anterior teeth (34.9%), thin pipette-shaped roots (30%), and short blunt roots (24%). The least frequent anomalies were supernumerary teeth (1%) and dilaceration (0.4%). The data, however, are not representative of the Libyan population.

Fteita et al. (2006) investigated the prevalence of molar incisor hypomineralization in a convenience sample of 378 school children aged between 7 and 9 years living in Benghazi, finding a prevalence of 2.9% (11 children); all the lesions were mild. Six of the 11 children had diffuse opacities, and three had hypoplastic defects in their first molars.

Gaps and Recommendation

There is a paucity of data on dental anomalies among Libyan children, and the generalizability of the few reports is problematic because samples are drawn from non-representative populations, such as orthodontic patients (Iman Abdelgader, 2015), or were a convenient sample (Fteita et al., 2006). Also, all studies were conducted in Benghazi, in the eastern region of Libya. Although Benghazi is the second largest Libyan city and its inhabitants are descended from various Libyan tribes and races, the findings of these studies may not apply to the entire Libyan population. There is, therefore, a need for studies with a representative sample of Libyans, using more rigorous methodology to determine the eruption profile of the primary and permanent dentition and the prevalence of dental anomalies. Conduct of such studies, however, will be hindered by the ongoing chaos in the country.

It is also important to determine the etiological factors of dental anomalies among Libyan children and their relationship with various oral dysfunctions, such as phonation, mastication and, possibly, future malocclusions. Findings should help form the training curricula of the dental workforce to enable them to diagnose and appropriately treat patients with dental anomalies. Previous studies have suggested that curricula in Libyan dental schools do not adequately prepare dentists to provide preventive dental services (Arheiam and Bernabé, 2015, Arheiam et al., 2015).

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Lithuania

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Background Information on Lithuania

Figure 1 is a map of Lithuania, a country in northeasten Europe with an area of 65.2 km^2. The country borders Latvija to the north, Belorus to the east and south, Poland to the south, and Russia to the west. Its coast in the west lies on the Baltic sea. The estimated population of Lithuania at the beginning of 2018 was 2.8 million. Lithuania's population is getting older. According to official data young people, 0-25-year-olds, account for 27% of the country's population, while those ≥65 years account for 20%. Life expectancy at birth is 74 years (Statistics Lithuania, 2018; World Bank Data, 2018). Vilnius – the largest town of the country (population 0.55 million) – is the capital city.

It is a high-income country and ranked 37 among the 188 countries on the Human Development Index (UNDP, 2017). Early neonatal deaths per 1000 live births were 2.93 in 2017 (Lithuanian Health Statistics, 2018). The Gross Domestic Product is US$ 42.773 billion with annual growth at 2.3%. 74.4% of the population are internet users (World Bank Data, 2018).

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Figure 1: Map of Lithuania

Timing and Sequence of Emergence of Primary and Permanent Dentitions

Almonaitiene et al. (2012), in a cross-sectional study on the timing and sequence of permanent teeth emergence, examined 3,596 Lithuanian children aged 4-16 years. Table 1 gives a summary of the study findings. The girls emerged their teeth earlier than the boys. The difference was found to be insignificant for the first permanent molars, upper central incisors, upper second molars and upper right first premolar. The lower teeth emerged earlier than the corresponding upper teeth with no gender difference, except for the first and second premolars among boys and the first premolars among girls. The first permanent teeth to emerge were the lower central incisors and the lower first molars. The difference in time of emergence between lower central incisors and lower first molars was insignificant among boys and significant among girls.The upper second molars were the last to emerge with no gender difference in their time of emergence (Almonaitiene et al., 2012).

Table 1. Median eruption time (years) of permanent teeth with CI (confidence interval)

Tooth	Boys		Girls	
	Age	CI	Age	CI
Upper right second molar	12.32	12.19-12.44	12.08	11.96-12.20
Upper right first molar	6.41	6.30-6.52	6.26	6.15-6.38
Upper right second premolar	10.82	10.68-10.97	10.63	10.49-10.77
Upper right first premolar	9.91	9.76-10.05	9.51	9.37-9.65
Upper right canine	11.09	10.96-11.22	10.51	10.38-10.64
Upper right lateral incisor	7.96	7.83-8.08	7.55	7.43-7.66
Upper right central incisor	6.89	6.78-7.0	6.75	6.64-6.87
Upper left central incisor	6.84	6.73-6.95	6.74	6.62-6.85
Upper left lateral incisor	7.97	7.86-8.08	7.51	7.37-7.63
Upper left canine	11.02	10.89-11.15	10.48	10.35-10.60
Upper left first premolar	9.87	9.73-10.02	9.55	9.41-9.69
Upper left second premolar	10.98	10.84-11.12	10.61	10.46-10.75
Upper left first molar	6.45	6.34-6.55	6.20	6.09-6.30
Upper left second molar	12.26	12.14-12.38	12.04	11.92-12.16
Lower left second molar	11.69	11.57-11.81	11.28	11.16-11.41
Lower left first molar	6.21	6.09-6.33	5.99	5.89-6.10
Lower left second premolar	11.06	10.92-11.20	10.56	10.41-10.70
Lower left first premolar	10.12	9.99-10.26	9.65	9.51-9.79

Tooth	Boys		Girls	
	Age	CI	Age	CI
Lower left canine	10.37	10.25-10.50	9.58	9.45-9.71
Lower left lateral incisor	7.20	7.09-7.31	6.86	6.73-7.0
Lower left central incisor	6.13	6.02-6.23	5.87	5.75-5.98
Lower right central incisor	6.07	5.97-6.18	5.82	5.71-5.93
Lower right lateral incisor	7.22	7.10-7.34	6.83	6.70-6.95
Lower right canine	10.35	10.23-10.48	9.51	9.38-9.63
Lower right first premolar	10.11	9.97-10.25	9.60	9.47-9.73
Lower right second premolar	11.07	10.93-11.20	10.60	10.46-10.74
Lower right first molar	6.29	6.17-6.41	6.09	5.98-6.20
Lower left second molar	11.64	11.52-11.76	11.26	11.14-11.38

The sequence of eruption differed between boys and girls as presented below:

I_1, M_1, M^1, I^1, I_2, I^2, P^1, P_1, C_1, P^2, P_2, C^1, M_2, M^2 – Boys
I_1, M_1, M^1, I^1, I_2, I^2, P^1, C_1, P_1, C^1, P_2, P^2, M_2, M^2 – Girls

Developmental Hard Dental-tissue Anomalies

Dental fluorosis: Dental fluorosis is caused by excessive ingestion of fluoride during the tooth mineralization period (Thylstrup and Fejerskov, 1978). Drinking water in Lithuania contains naturally occuring fluoride (0.43 ppm on average), with variation within regions. The northwestern region is a high fluoride area, with a fluoride content of 0.7 ppm to 5.6 ppm (Juodkazis and Kucingis, 1999). The southwestern region has about 1.1 ppm. The southern and central regions of the country are a low-fluoride area, with a fluoride content in drinking water ranging from 0.16 ppm to 0.18 ppm and 0.3 ppm (Narbutaite, Vehkalahti and Milčiuvienė, 2007; Machiulskiene et al., 2009).

Narbutaite (2000) conducted a study on dental fluorosis in 1,804 school children aged 6-7 years, 12 years and 15 years in low- and high-flouride areas of the country, using the Thylstrup and Fejerskov scoring system (Thylstrup and Fejerskov, 1978) for fluorosis. Table 2 gives a summary of the study findings. The prevalence and pattern of fluorosis in the primary and permanent dentition of 6-7-year-old children were assessed. In the primary dentition, the scores on dental fluorosis ranged from 1 to 3. The teeth most affected were the first and second molars in both the upper and lower jaws. In the permanent dentition, the scores on dental fluorosis ranged from 1 to 6, although the most common scores were 1 and 2. The most affected teeth were the central incisors, lateral incisors and first molars (Narbutaite, 2000).

Table 2. Prevalence of dental fluorosis among school children in low- and high-fluoride areas in Lithuania

Area	Age		
	6-7 year olds	12 year olds	15 year olds
High fluoride area: 1.7-2.2 ppm	Primary teeth: 9.9% Permanent teeth: 44.7% (n = 302)	67.1% (n = 301)	58.1% (n = 283)
Low fluoride area: 0.16-0.18 ppm	Primary teeth: 0% Permanent teeth: 0.3% (n = 301)	3.7% (n = 299)	3.7% (n = 301)

In 12- and 15-year-old children, the first and second premolars and the second molars were most affected. There was no significant difference in the prevalence of fluorosis in the mandible and maxilla. Scores 1, 2 and 3 were the most prevalent. A few cases of scores 6 and 7 were recorded in the premolars and second molars. The least-affected teeth were the central and lateral incisors in the mandible and the first molars in the mandible and maxilla. The teeth that were mineralized much later in life were worst affected by fluorosis (Narbutaite, 2000).

Machiulskiene et al. (2009) screened 300 teenagers for fluorosis, using the Thylstrup and Fejerskov (TF) scoring system. Study participants were recruited from areas where the fluoride level was 1.1 ppm and from areas where the fluoride level was 0.3 ppm. The prevalence of fluorosis was 45% in teenagers resident in areas where the fluoride level was 1.1 ppm, whereas it was 21% where the fluoride level was 0.3 ppm. All fluorotic lesions observed corresponded to TF scores 1 or 2.

Non-fluoride opacities and hypoplasia: Machiulskiene et al. (2009) also screened for non-fluoride opacities and hypoplasia. The prevalence was 19% and 16% respectively, in the area with 0.3ppm fluoride; and 8% and 12% respectively, in the area with a fluoride level of 1.1 ppm.

Molar incisor hypomineralization: Jasulaityte et al (2007) screened for molar incisor hypomineralization in 1,277 school children aged 7 to 9 years, using the European Academy of Pediatric Dentistry criteria (Weerheijm et al., 2003). The first permanent molars and all permanent incisors were examined for demarcated hypomineralization lesions, demarcated opacities, post-eruptive enamel breakdown, atypical restorations and extractions due to molar incisor hypomineralization. The prevalence of demarcated hypomineralization lesions was 14.9%, and that of molar incisor hypomineralization was 9.7%.

Gaps and Recommendation

The studies conducted do not include a nationally representative sample: data presented cover only populations in certain regions of the country. National studies on primary and permanent tooth emergence profiles, tooth emergence anomalies and developmental hard dental-tissue anomalies are required.

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MALAYSIA

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Background Information on Malaysia

Malaysia is a Southeast Asian country that covers a land area of 330,803 km^2. Its mainland, known as Peninsular Malaysia is separated from East Malaysia by the South China Sea (Figure 1). Malaysia has thirteen states and three federal territories. Kuala Lumpur is the capital of the country, though Putrajaya is the headquarters of the federal government and its administration. Malaysia's political system is based on a parliamentary democracy and a constitutional monarchy: the head of government is the Prime Minister and the head of state is the King, or the Yang di-Pertuan Agong. The King serves a five-year term and is selected by, and from,

Figure 1. Map of Malaysia

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nine state rulers, or Sultans, based on a rotational system. The Prime Minister is appointed by the King on the grounds of obtaining the majority of the lower house of parliament. The parliament consists of the lower house (the House of Representatives or "*Dewan Rakyat"*) and the upper house (the House of Senate or "*Dewan Negara"*) and is elected every five years. The last general election was held on 9 May 2018, and Tun Dr. Mahathir Mohamad, who was the fourth Prime Minister of Malaysia, was appointed the Prime Minister again.

In 2017, the total population of Malaysia was estimated to be 32.0 million, a 1.3% increase from 2016 (Department of Statistics Malaysia, 2017a). Birth and death rates were estimated to be 19.1 births/1,000 population and 5.1 deaths/1,000 population (Central Intelligence Agency, 2018). Malaysia is a multi-racial country with cultural and ethnic diversity. The three main ethnic groups are Malays, Chinese, and Indians. There are also indigenous groups, which add to Malaysia's multi-ethnicity. These include the Semang, Senoi and Melayu Proto in Peninsular Malaysia; the Bajau, Kadazan-Dusun and Murut in Sabah; and the Dayak (Iban and Bidayuh) and Melanau in Sarawak. According to the 2017 Malaysian demography, Bumiputera (Malays and other indigenous groups) comprise 68.8% of the total population, followed by Chinese (23.2%), Indians (7.0%), and other races (1.0%) (Department of Statistics Malaysia, 2017a). The percentage of children under 18 years of age decreased from 29.9% in 2016 to 29.4% in 2017 (Department of Statistics Malaysia, 2017b). The age distribution of the population in 2017 was: 0-4 years, 8.2%; 5-9 years, 7.9%; 10-14 years, 8.0%; and 15-19 years, 8.9% (Department of Statistics Malaysia, 2017c).

Since Malaysia gained its independence in 1957, its economic base has changed from agriculture and mining to industry and manufacturing. Malaysia is rich with natural agricultural resources, such as natural rubber, timber, and palm oil. It also has substantial mineral resources, including tin, petroleum, and natural gas. Although the agricultural sector is no longer the major economic contributor for the country, Malaysia was the world's second largest palm oil exporter in 2016 (32.6% of the world's total palm oil exports, valued at USD9.1 billion). Malaysia's gross domestic product grew from 4.2% (valued at USD267.0 billion and RM1,108.2 billion) in 2016 to 5.7% (valued at USD267.0 billion and RM1,168.4 billion) in 2017 (Economic Planning Unit, 2017). According to the Household Income and Basic Amenities Survey 2016, the mean monthly household income rose from RM6,141 in 2014 to RM6,958 in

2016, a 6.2% increase (Department of Statistics Malaysia, 2017d). Also, the incidence of poverty decreased from 0.6% in 2014 to 0.4% in 2016. Malaysia's unemployment rate was unchanged in 2016 at 3.4% of the labor force (Economic Planning Unit, 2017).

In 1991, the Prime Minister envisioned the Vision 2020 ideal, whereby Malaysia would be a self-sufficient, industrialized nation. As the country strives to meet this ideal, it has undergone rapid transformations in demography, economy, education, and social well-being. Lifestyle changes, including modifications to dietary habits and nutritional intake, have also occurred. In 2006 and 2015 the National Health and Morbidity Surveys collected data about the nutritional status of children below 5 years of age (Figure 2) (Nutrition Division, 2016). After almost a decade, little had changed, and Malaysia is still dealing with malnutrition in young children. For example, the prevalence of underweight (less than the 5th percentile of the BMI-for age) children was 12.4% in 2015 compared to 12.9% in 2006, and the prevalence of stunting (height for age <-2 standard deviations) rose from 17.2% in 2006 to 17.7% in 2015. Childhood stunting can lead to impaired health and education and subpar economic performance in later life (Dewey and Begum, 2011).

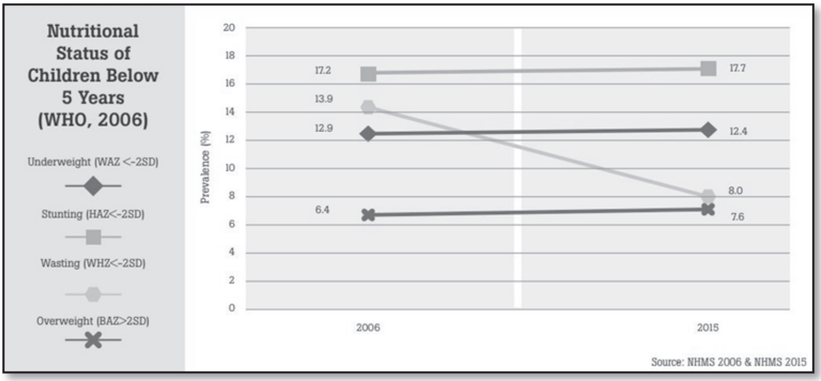

Figure 2. Nutritional status of children below 5 years old (Nutrition Division, 2016)

It is encouraging, though, that from 2011 to 2015 the prevalence of stunting, and wasting (BMI for age <-2 SD), in Malaysian school children decreased (Figures 3 and 4). On the other hand, the prevalence of childhood obesity increased (Figure 5). This trend is concerning and highlights that children are increasingly growing up in an obesogenic environment.

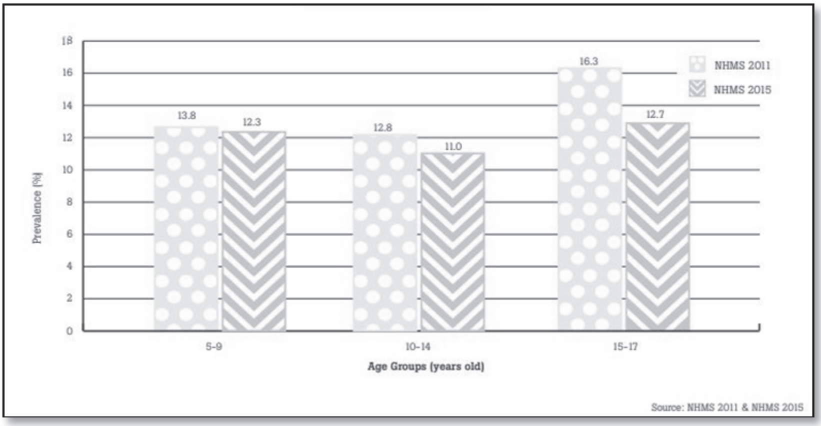

Figure 3. Prevalence of stunting (height for age >2 SD) by age groups (Nutrition Division, 2016)

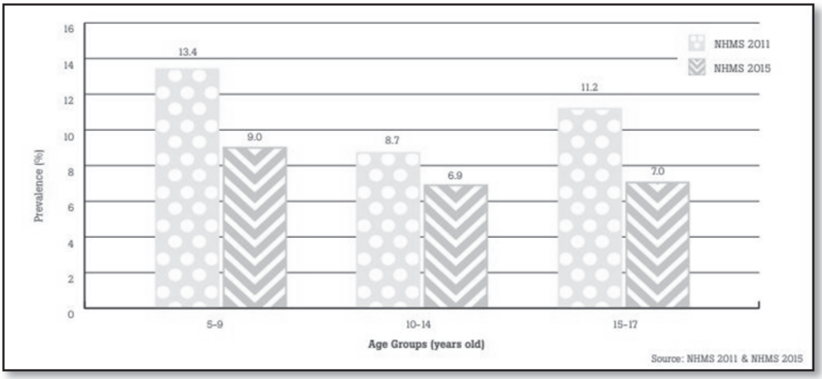

Figure 4. Prevalence of wasting (BMI for age <-2 SD) by age groups (Nutrition Division, 2016)

Fluoridation of Malaysia's public water supply was introduced in 1972, and the standard fluoride level was set at 0.7 ppm until 2004. In 2005, it was adjusted to an optimal level of 0.5 ppm (Malaysian Dental Council, 2009). Thereafter, the percentage of the population that had access to fluoridated water gradually increased until 2014 when fluoridation ceased in one of the states (Figure 6).

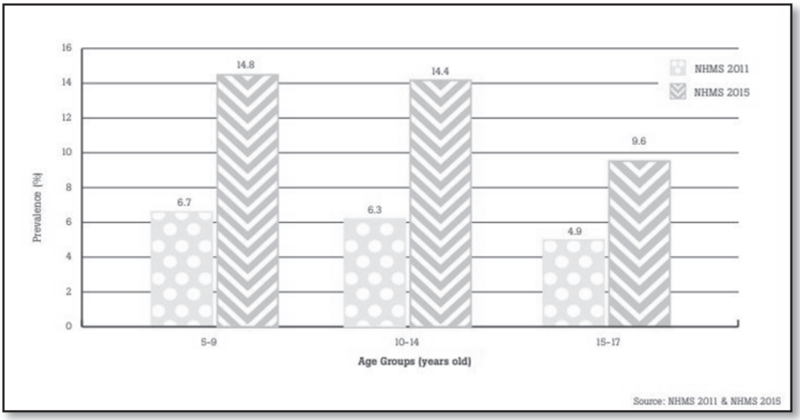

Figure 5. Prevalence of obesity (BMI for age >2 SD) by age groups (Nutrition Division, 2016)

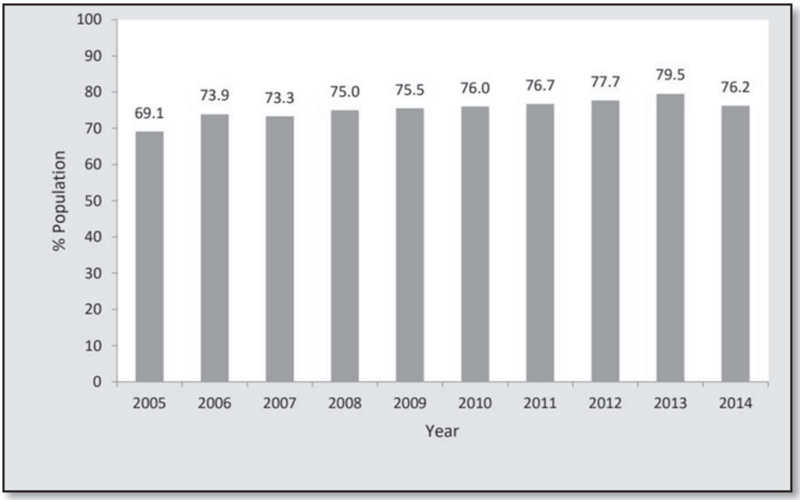

Figure 6. Population coverage for the water fluoridation programme, 2005-2014 (Oral Health Division, 2015)

Shahruddin et al. (2010) studied the fluoride concentration in public drinking water from nine sites in seven Malaysian states. They found that every site had a lower mean fluoride concentration than that recommended by Malaysia's Ministry of Health, which is 0.5-0.9 mg/l. Kota Kinabalu, the state capital of Sabah, had the lowest mean fluoride concentration, at 0.08 $\pm$ 0.06 mg/l (Shahruddin et al., 2009). The challenges faced by states with poor access to fluoridated drinking water are mainly financial and technical.

The Oral Health Division of the Ministry of Health Malaysia had been given the mandate to enhance optimal oral health in all age groups by providing different services encompassing primary and community oral healthcare. For children, these programs commence during the antenatal stage and are continued though the toddler program and dental services in preschool, primary, and secondary school (Oral Health Division, 2006). These responsibilities are carried out by dental nurses, dental officers, dental surgery assistants, and dental specialists. Various oral health-care phases have been set up by the State Deputy Director of Oral Health to facilitate the delivery and provision of oral healthcare to children. Compliance with these phases helps to identify children at high risk for oral health issues who may benefit from preventive measures. Compliance also facilitates the early detection of dental anomalies and proper referrals to dental officers or dental specialists who can provide further clinical management (Oral Health Division, 2006).

Timing and Sequence of Emergence of Primary and Permanent Dentitions

Data on the timing and sequence of emergence of primary teeth in Malaysia do not exist. There are, however, a few studies on the timing and sequence of emergence of the permanent dentition in Kota Bharu, Kelantan. The first published data were from a cross-sectional investigation of the age and sequence of eruption of permanent teeth in 5-17-year-old Malay children, the largest ethnic group in Kelantan (Nizam, Naing and Mokhtar, 2003). Subsequently, Hussin et al. (2007) evaluated the timing and sequence of emergence of the first 28 permanent teeth in a cross-sectional study of 1,386 Malay schoolchildren, aged 5-19 years, who resided in Kota Bharu (Table 1). Overall, the authors found that the time of emergence of the first 28 permanent teeth was the same (5.97 years) in Malay boys and girls, but tooth emergence in Malay female children was earlier than in male children. These findings were similar to those of children in other Asian countries (Jaswal, 1983; Gaur and Singh, 1994; Diamanti and Townsend, 2003; Almonaitiene, Balciuniene and Tutkuviene, 2012; Bruna del Cojo et al., 2013; Dashash and Al-Jazar, 2017).

Table 1. Median age of tooth eruption in male and female Malay school children

Tooth	Median age, years (95% CI)	
	Boys	Girls
Maxilla		
Central incisor	7.20 (6.96, 7.43)	6.96 (6.64, 7.22)
Lateral incisor	8.59 (8.34, 8.83)	7.85 (7.58, 8.08)
Canine	11.37 (11.12, 11.62)	10.95 (10.77, 11.14)
First premolar	10.06 (9.83, 10.30)	9.54 (9.35, 9.73)
Second premolar	10.96 (10.72, 11.20)	10.59 (10.40, 10.79)
First molar	6.83 (6.59, 7.03)	6.51 (6.25, 6.71)
Second molar	12.49 (12.27, 12.73)	12.22 (12.03, 12.42)
Mandible		
Central incisor	6.71 (6.41, 6.96)	6.47 (6.12, 6.73)
Lateral incisor	7.62 (7.38, 7.84)	7.23 (6.98, 7.44)
Canine	10.60 (10.39, 10.80)	9.78 (9.60, 9.95)
First premolar	10.15 (9.88, 10.42)	9.75 (9.55, 9.94)
Second premolar	11.08 (10.83, 11.32)	10.57 (10.38, 10.76)
First molar	6.52 (6.04, 6.86)	6.25 (5.83, 6.55)
Second molar	11.56 (11.31, 11.80)	11.29 (11.11, 11.47)

Source: Hussin et al., 2007

In the Hussin et al. (2007) and Nizam, Naing and Mokhtar (2003) studies, the earliest tooth to emerge in both boys and girls was the mandibular first permanent molar, and the last tooth to erupt was the maxillary second molar. This pattern was like that reported for Nepalese (Upadhyay et al., 2016) and Lithuanian (Almonaitiene, Balciuniene and Tutkuviene, 2012) children; however, it differed from that observed in Australians and Syrians. In Australian girls and boys, the earliest teeth to emerge were the central incisors and first molars, whereas the second premolars, second molars, and maxillary canines emerged last (Diamanti and Townsend, 2003). In male and female Syrian school children, the mandibular central incisors and first molars were the earliest teeth to emerge and the second molars were the last (Dashash and Al-Jazar, 2017).

In the Hussin et al. (2007) study, the median age of emergence of the first permanent tooth, the mandibular first molar, was 6.52 years in males and 6.25 years in females. For the last permanent tooth, the maxillary second molar, it was 12.49 years in males and 12.22 years in females (Table 1). In contrast, Nizam, Naing and Mokhtar (2003) reported an earlier emergence time of the mandibular first molar at 6.0 years. The sequence of tooth eruption reported by Nizam, Naing and Mokhtar (2003) is represented below:

$M_1\ M^1 I_1\ I^1\ I_2 I^2\ P^1 P_1\ C\downarrow\ P^2 P_2 C\uparrow\ M_2 M^2$ for boys
$M_1\ M^1 I_1\ I^1\ I_2 I^2\ P^1 C\downarrow\ P_1 P^2 C\uparrow\ P_2 M_2 M^2$ for girls

The sequence reported by Hussin et al. (2007) was different from that of Nizam, Naing and Mokhtar (2003) and is represented below:

$M_1\ M^1 I_1\ I^1\ I_2 I^2 P^1\ P_1\ C\downarrow\ P^2 P_2 C\uparrow\ M_2 M^2$ for boys
$M_1 I_1\ M^1\ I^1\ I_2 I^2 P^1\ P_1\ C\downarrow\ P_2\ P^2 C\uparrow M_2\ M^2$ for girls

Nizam, Naing and Mokhtar (2003) reported that all mandibular teeth emerged earlier than their maxillary counterparts, except for the first and second premolars. They also found a gender difference in the sequence of tooth eruption after the mean age of 9.5 years in males and 9.2 years in females. Hussin et al. (2007) did not find this difference, nor were differences found in Khasi (Jaswal, 1983) and Manipur (Gaur and Singh, 1994) in Northeastern India.

Developmental Dental Hard-tissue Anomalies

The earliest Malaysian study on hypodontia of permanent dentition was by Nik-Hussein (1989), who determined that the prevalence of hypodontia in Malaysian children between the ages of 5 and 15 years was 2.8%. The prevalence was higher in females than in males (ratio 1.6:1). The maxillary lateral incisor was the most frequently missing tooth, followed by the mandibular lateral incisors and the mandibular second premolars.

Mani, Mohsin and John (2014) evaluated the orthopantomograms of 834 healthy Malay children, aged 12-16 years, to determine the prevalence and patterns of tooth agenesis. The mean tooth agenesis per child was 2.3. The most prevalent tooth agenesis was that of the third molars (25.7%), followed by the maxillary lateral incisors (1.7%), the maxillary and mandibular second premolars (1.5%), and the maxillary canines (1%).

When the third molar was excluded, 3.2% of children had agenesis of other teeth. Bilateral tooth agenesis was more common than unilateral agenesis, a trend that was also observed in the study by Nik-Hussein (1989). The prevalence of tooth agenesis was not significantly different between boys and girls; however, it was for maxillary vs. mandibular teeth and for the side of the mouth affected. Tooth agenesis was more prevalent in the maxillary region and on the right side.

There are no recent data about the prevalence of a supernumerary tooth, anomalies of tooth size (microdontia and macrodontia), anomalies of tooth shape (fusion, gemination, concrescence, dens invaginatus, and dens evaginatus), or dentine defects of the primary dentition in Malaysians. Available studies are more than two decades old and involved few subjects. In 1996, Nik-Hussein and Abdul Majid reported 79 cases of double teeth, hypodontia, and a supernumerary tooth of the primary dentition in 65 children. They also described the correlations of dental anomalies in the primary teeth and the development of succedaneous permanent teeth. Notably, all children who had hypodontia of their primary teeth developed hypodontia of their permanent teeth. Conversely, 50% of the children with a primary supernumerary tooth and 59% of the children with a primary double tooth exhibited anomalies of succedaneous permanent dentition.

A retrospective study of a double primary tooth in 20 children aged from 2.5 to 9 years showed that fusion was more prevalent than gemination (Razak and Nik-Hussein, 1986). The frequency of a double tooth was higher in boys than in girls, higher in the mandible than in the maxilla, and similar in the right and left jaw. Lateral incisors and canines were the most common teeth associated with fusion.

Enamel defects: Several studies have used the Modified Developmental Defects of Enamel Index to evaluate the prevalence, and pattern, of enamel defects in Malaysian states. As illustrated in Table 2, the prevalence of enamel defects ranged from 56.0% to 90.7%. A lower prevalence of 40.3% was reported by Nik-Hussein and Razak (1989), who examined 11-12-year-old Malaysian school children. In that study, the most severely affected teeth were the first permanent molars, and significant differences in the prevalence of enamel defects were not found between the genders. Also, there was a high tendency toward a symmetrical distribution of enamel defects in contralateral tooth pairs.

In a fluoridated northern state of Malaysia, the prevalence of enamel defects was 76.4%, and the tooth level prevalence was 19.1% (Majid, Hussein and Bagramian, 1996). Enamel defects were more common in posterior teeth than in anterior teeth. Defects were also more common in maxillary teeth than in mandibular teeth. The risk for caries was the same in teeth with and without enamel defects.

Yusoff et al. (2008) investigated the prevalence of enamel opacities in 957 11-12-year-old school children who resided in a fluoridated area of Kuala Lumpur. The subjects were from the three main ethnic groups in Malaysia: Malay, Chinese, and Indian. Overall, the prevalence of enamel opacities was 90.7%, while the tooth level prevalence was 47.2%. The most common type of enamel defect was diffuse opacities (88.6%), and 70% of study participants had lesions that indicated a systemic etiology. Also, the posterior teeth were affected twice as often as the anterior teeth. The highest prevalence of enamel opacities was observed in Malays (94.5%), followed by Indians (90.9%), and Chinese (86.6%) ($p < 0.01$). These findings differed from those of the National Oral Health Survey of School Children (1997), which found a higher prevalence of enamel opacities in the Chinese than in the Malays (64.6% vs .57.5%) (Oral Health Division, 1998).

Molar incisor hypomineralization: Hussein et al. (2015) screened 150 patients, aged 7-12 years, for molar incisor hypomineralization. The prevalence was 16.9%, and significant differences were not found between the genders nor were there antimeres. The mandibular molar had the highest frequency of the lesion (31.0%), followed by the maxillary molar (27.7%), the mandibular central incisor (12.9%), the maxillary central incisor (10.8%), the mandibular lateral incisor (10.1%), and the maxillary lateral incisor (7.5%).

Fluorosis: The earliest national data on fluorosis were collected in 1971; the Dean's Index was used to evaluate fluorosis in 6-18-year-old school children in West Malaysia. No evidence of fluorosis was found (Dental Services Division, 1972). In subsequent years, the prevalence of fluorosis increased as shown in Table 3 (Oral Health Division, 2005). In 1999, the prevalence of fluorosis was 74.7% in areas with fluoridated water and 14.2% in areas without fluoridated water (Oral Health Division, 2001). Also, 94.1% of children in the fluoridated areas had "questionable to mild"

Table 2. Studies on the prevalence of enamel defects in Malaysian school children

Authors	Geographic regions	Age of subjects (years)	Number of subjects	Prevalence of enamel defects	
				Mouth	Tooth
Dental Services Division, Johore, 1986	Johore	11-12	2,388	83.1%	29.9%
Abdul Razak and Nik-Hussein, 1986	Petaling Jaya, Selangor	11-12	1,024	72.5%	40.4%
Yusoff et al., 2008	Kuala Lumpur	11-12	957	90.7%	47.2%
Majid, Hussein and Bagramian, 1996	Penang	12-15	229	76.4%	19.1%
Oral Health Division, 1998	Malaysia	16	4,085	56.0%	21.8%
Sujak, Abdul Kadir and Dom, 2004	Penang	16	1,024	67.1%	64.5%

Source: Oral Health Division, Ministry of Health Malaysia, 2005

fluorosis; 53.6% fell under the very mild category. In the fluoridated regions, the Community Fluorosis Index was 0.95, which indicated that fluorosis was of "slight" public health significance.

A few years later, Esa and Razak (2001) assessed the prevalence of dental fluorosis and its association with caries in 1,519 12-13-year-old children who attended school in fluoridated urban and rural areas in the Klang District. The overall prevalence of fluorosis was 32.8%, and 31.3% of study participants had very mild to mild fluorosis, 1.4% had moderate fluorosis, and 0.1% had severe fluorosis. Also, 13.2% had questionable fluorosis, and 54% had no fluorosis. The Community Fluorosis Index in this region was 0.48, which connoted "borderline" public health significance. There was no significant correlation found between fluorosis and caries.

In 2005, Tan, Razak and Foo (2005) reported the prevalence of fluorosis in 10-11-year-old school children in a fluoridated area in Selangor. The prevalence of fluorosis was 58.7%, and the tooth prevalence was 30.1%. These data suggest that the level of fluoride exposure was slightly above the optimum. The Community Fluorosis Index ranged from 0.23 to 1.72, and 50% of the schools had scores greater than 1.0, which indicated that fluorosis was of "medium" public health significance in this region.

Gaps and Recommendation

Data about the timing and sequence of primary tooth emergence are scarce, and this paucity has implications for treatment planning in children. Additionally, the timing and sequence of primary tooth emergence in Malaysian children have not been studied. Malaysia is a multi-racial country; however, most of the studies on permanent teeth emergence involved children from the Malay ethnic group. Studies that represent Malaysia's various ethnic groups are needed so that reference standards for primary and permanent tooth emergence can be established.

There is also a paucity of data on developmental dental hard-tissue anomalies. Although some studies of tooth agenesis are recent, the sole survey of supernumerary teeth was conducted over 30 years ago (Hussein, 1985). Several studies about enamel defects have been published, yet few data have been reported about enamel hypoplasia and molar-incisor hypomineralization. Community-wide studies are required to bridge these gaps; additional information is vital so the clinical management of children with eruption problems and dental anomalies can be optimized.

Table 3. Studies on the prevalence of fluorosis in Malaysian school children using the Dean's Index

Authors	Age of subjects (years)	Number of subjects	Fluorosisprevalence, (%)	Dean's Index fluorosis score						Community flouride index	Public health significance
				Normal	Questionable	Very mild	Mild	Moderate	Severe		
				0	0.5	1	2	3	4		
Dental Services Division, 1972	6-18	15,917	0%	-	-	-	-	-	-	0.0	
Oral Health Division, 2001	16-17	2,153	74.7% (F area)	25.3%	12.4%	40.1%	17.8%	4.2%	0.2%	0.95	Slight
		756	14.2% (Non-F area)	85.8%	11.2%	2.5%	0.4%	-	-	-	-
Esa and Razak, 2001	12-13	1,519	32.8% (F area)	54.0%	13.2%	25.7%	5.6%	1.4%	0.1%	0.48	Borderline
Tan, Razak and Foo, 2005	10-11	1,343	58.7% (F area)	41.3%	0%	35.6%	14.6%	7.6%	0.9%	0.96	Slight

F = Fluoridated, Non-F = Non-fluoridated; Source: Oral Health Division, Ministry of Health Malaysia, 2005

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MEXICO

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Background Information on Mexico

Mexico, with more than 124 million habitants, is the most populated Spanish speaking country and the 11th most densely populated. The human presence in Mexico goes back to 14,000 years BC. After thousands of years of cultural development, Aridoamerican and Oasisamerican Mesoamerican cultures arose in Mexican territory. The current territory of Mexico was the main and greatest stage of the Mexican people and, in part, of the Mayan people, the two most important civilizations of pre-Columbian America. After almost 300 years of Spanish domination, Mexico, without mentioning the presence of a miscegenation, began the struggle for its political independence in 1810. Subsequently, for nearly a century the country was involved in a series of internal wars and foreign invasions that had repercussions in all areas of life for Mexicans. Figure 1 is a territorial map of Mexico.

Mexico is made up of a mixture of races. The epidemiology of dental anomalies helps to highlight possible ethnicity-related oral health risk factors. For example, Mongoloids have an increased risk for shovel-shaped incisors, an absence of second premolars, maxillary hypoplasia resulting in root dilaceration and ectopic teeth. Other anomalies are peculiar to those with European heritage such as peg-shaped teeth and supernumerary teeth.

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Figure 1: Map of Mexico

Timing and Sequence of Emergence of Primary Dentition

There are few studies in Mexico of the eruption sequence of the primary and permanent dentition. These studies are mainly cross-sectional. Valdez et al.'s (2014) study showed that there were no significant differences in the findings of cross-sectional and longitudinal studies conducted on the same population as shown in Figure 1.

Vaillard et al. (2008) reported a positive correlation of weight and height with the timing of tooth emergence in 60% of the population. The authors concluded that tooth-emergence patterns were related to the growth and development of the maxilla and mandible. This is illustrated in Table 2.

Studies such as that of Garcia et al. (2002), conducted on children in Mexico City, found that the development and eruption of permanent dentition were like the original paper calculating dental age by Nolla (1960), However, Adriano, Caudillo and Caudillo (2015) found that the chronology of tooth emergence in school children in Mexico City was delayed compared with that of children in Hume's tables, and the delay was correlated with the shorter height and lower weight of the children.

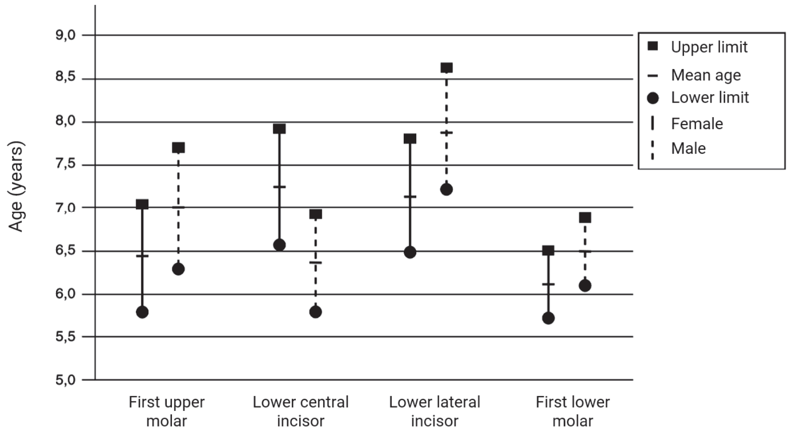

Figure 1. Mean age and ranges of dental eruption by sex and types of teeth analyzed by the transversal method

Table 2 Age average of eruption by sex of the Ixtapalapa (Mexico) school children compared with the Hume tables

Dientes	Iztapalapa F	Iztapalapa M	Hurme F	Hurme M
Upper Arch				
Centrals	9,20±2,5	9,32±2,6	7,20	7,47
Laterals	9,61±2,9	9,82±2,9	8,20	8,67
Canines	**10,87***±2,2	**11,01***±1,9	10,98	11,69
First premolars	10,46±2,7	10,54±2,6	10,03	10,40
Second premolars	**10,64***±2,4	**10,72***±2,3	10,88	11,18
First Molars	8,87±2,0	8,94±2,0	6,22	6,40
Second Molars	11,19±1,2	11,35±1,1	12,27	12,68
	t= df=2951; p=0,000			
Lower Arch				
Centrals	8,8±1,8	8,9±1,9	6,26	6,54
Laterals	9,2±2,5	9,3±2,6	7,34	7,70
Canines	10,9±2,0	11,0±1,8	9,86	10,79
First premolars	10,14±2,4	10,13±2,5	10,18	10,82
Second premolars	**10,63***±2,4	**10,76***±2,2	10,89	11,47
First Molars	8,8±1,9	8,9±1,9	5,94	6,21
Second Molars	11,02±1,6	11,17±1,4	11,66	12,12
	t= df=29,63; p=0,000			

Developmental Dental Hard-tissue Anomalies

There are also studies in Mexico that accurately highlight the prevalence of developmental dental anomalies of hard tissue. The few studies often show contradictory results due to differences in methodology, sample size, study population and age group.

Murrieta et al. (2006) reported a general prevalence of dental anomalies of 43:1000. Herrera et al. (2014) reviewed the orthodontic cases of 670 children aged 4 to 14 years attending at the University Autonoma de Yucatan Mexico. Of these, 28.05% had at least one dental anomaly with the prevalence being higher for females (62.76%) than for males (37.23%). Duque et al. (2016) conducted a retrospective study and reviewed the clinical records of 749 children aged 4 to 14 years. They found that 17.3% of patients presented with one or more dental anomalies. More males than females had dental anomalies (60% vs. 40%) The most frequent anomalies observed were structural anomalies (54%) followed by anomalies of number (20%), shape (20%) and size (8%).

Anomalies of Tooth Numbers

Agenesis: Dental agenesis is one of the most common dental anomalies reported in Mexico. Feregrino et al. (2016) reported an incidence of 15.53% based on a study of 865 panoramic radiographs of patients attending the Orthodontic clinic at the Universidad Autonoma de Nayarit-Mexico. The highest prevalence of 70.83% was in females and the tooth most affected was the third molar (62.26%) followed by the maxillary laterals (9.42%) and the second premolars (4.73%).

The prevalence reported by Herrera et al. (2014) was lower – 5.82% with 71.21% of the lesions in the mandible and 28.79% in the maxilla. The most frequent missing tooth was the second mandibular premolar (25.75%) followed by the maxillary (10.6%) and mandibular lateral incisors (22.72%). The prevalence of missing mandibular second permanent molar agenesis was 10.6%.

Supernumerary: Vigueras, Fernandez and Villanueva (2015) reviewed 608 panoramic radiographs of patients with cleft lip and palate from the Gea Gonzalez Hospital at Mexico and reported that the prevalence of supernumeraries was higher in males (53.9%) than in females (46.1%). There was no difference in the prevalence of supernumerary teeth by the side of the jaw. The prevalence was higher in the primary dentition (51.5%) and the upper lateral incisor was most affected (84.8%). The prevalence was the same for all types of supernumeraries (rudimentary, conical shaped or supplementary).

A comprehensive study on developmental dental anomalies was conducted by Ledesma et al. (2016). The study included 3,522 participants with ages ranging from 2 to 78 years. One or more dental anomalies were found in 5.1% of the sample. The prevalence was higher in females (54%) than in males (45.2%). The prevalence of supernumerary teeth of the population of participants with dental anomalies was 27.2%. Of these, 53.5% had a mesiodens while 23.3% had two mesiodens. Also, 18.6% of these mesiodens were inverted while 4.6% were fused with other teeth. The prevalence of bicuspid supernumeraries was 8.1% of which 70% were in the mandible, 60% of participants presented with one supernumerary bicuspid, and 20% presented with two or three bicuspid supernumeraries respectively. Also, 2.3% of participants had supernumerary incisors, 88.9% of which were in the permanent dentition and 66.7% were in the maxilla. Paramolars were maxillary teeth with a prevalence of 0.8%.

Herrera et al. (2014) reported a prevalence of 5.97% of supernumeraries with the frequency higher in the maxilla (73.33%) than in the mandible. The most prevalent type of lesion was the mesiodens. Murrieta et al. (2006) reported a prevalence of 0.31%.

Hypodontia: Ledesma et al. (2016) reported a prevalence of 22.8% of the patients with dental anomalies had hypodontia. Of the 90 missing teeth, 95.8% occurred in the permanent dentition and 4.2% were in the primary dentition. The prevalence of a missing lateral incisor was 33.3% followed by missing second bicuspids 11.5%. All the hyponditic lesions were in the mandibular. Murrieta et al. (2006) reported a prevalence of 3.28%.

Anomalies of Tooth Size

Microdontia: Ledesma et al. (2016) reported a prevalence of 3.3% in the 5.1% of 3,522 participants who had dental anomalies. The most frequently affected tooth was the permanent upper lateral incisor (69.2%) followed by lower and upper premolars (23.1%). Murrieta et al. (2006) reported a prevalence of 2.97%.

Macrodontia: Only one canine and one central incisor in the 3,522 participants were affected (Ledesma et al., 2016). Murrieta et al. (2006) reported a prevalence of 0.78% after examining 670 children between 4 and 14 years of age at the University Autonoma de Yucatan Mexico.

Anomalies of Tooth Shape

Herrera et al. (2014) reported a prevalence of tooth shape anomalies of 6.26%. Of the 42 cases, 18 had bilateral affectation. The prevalence of a unilateral lateral peg-shaped incisor was 1.49% and that of talon cusps was 1.04%.

Double teeth: The prevalence of double teeth was 8% of the dental anomalies reported by Ledesma et al. (2016). There were five cases in the primary dentition and two cases in the permanent dentition. All double teeth were found in the anterior segment of the jaws. Only 25% of cases were in the maxilla: the rest were found in the mandible (Ledesma et al., 2016). Herrera et al. (2014) reported a prevalence of only 0.3% while Murrieta et al. (2006) reported a prevalence of 15%.

Dilaceration: The prevalence was 0.5% of the 5.1% of participants who had dental anomalies. The most affected teeth were the premolars with a prevalence of 44.8%, followed by first and second molars with a prevalence of 27.6% (Ledesma et al., 2016).

Other shape-related anomalies: Murrieta et al. (2006) reported a prevalence of conical-shaped teeth of 0.78%, barrel-shaped teeth of 4.38% and shovel incisor shaped teeth of 62.59%. The prevalence of dens evaginatus was 2.5%.

Anomalies of Tooth Structure

Herrera et al. (2014) reported a prevalence of dental structural anomalies of 0.44% with no gender differences observed.

Amelogenesis imperfecta: The prevalence was 2.2% of the 5.1% of participants who had dental anomalies (Ledesma et al., 2016).

Dentinogenesis imperfecta: Three of 3,522 participants had dentinogenesis imperfecta, two of which were a mother and child (Ledesma et al., 2016). Murrieta et al. (2006) reported a prevalence of 0.62%.

Enamel hypoplasia: Murrieta et al. (2006) reported a prevalence of 3.59%. He also reported a prevalence of 81.69% of fluorosis and a prevalence of 0.15% of tetracycline stains.

Other Anomalies

Ectopic tooth: The prevalence of ectopic tooth was 1.5% of the 5.1% participants who had dental anomalies. The most frequently affected teeth were the canines. Two premolars and one incisor were also affected (Ledesma et al., 2016).

Enamel Pearls: The prevalence of enamel pearls was 1% of the 5.1% of participants who had dental anomalies. They pathology only affected the primary mandibular molars (Ledesma et al., 2016).

Transposition: The prevalence of transposition was 2.38% and it only occurred in the maxilla. The most frequently transposed teeth were the lateral incisors followed by the canine and premolars (Herrera et al., 2014).

Tooth emergence related anomalies: Herrera et al. (2014) reported a prevalence of an abnormal tooth emergence sequence of 13.58%, with 78.0% of the anomalies in the maxillary arch and 21.95% in the mandibular arch. The most affected teeth were the maxillary cuspid in 48.78% of cases followed by the central incisor and second premolar with a prevalence of 13% respectively.

Gaps and Recommendations

Mexico is an old country with a very long history. The presence of several pre-Hispanic civilizations, cultures, wars, and conquests, has created a melting pot of many ethnic groups. This phenomenon creates many variables which prevent the generation of precise data collection on tooth eruption, tooth emergence and dental tissue anomalies. For this reason, bioarcheological studies of the primary and permanent dentition of Mexicans will be of huge importance. Currently, most studies on tooth eruption, tooth emergence and dental tissue anomalies are cross-sectional. Retrospective analysis of data and the prospective generation of data from indigenous Indian populations protected by the Mexican constitution in the different states of Mexico will yield rich and important information.

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Morocco

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Background information on Morocco

Morocco is a country in northwestern Africa, with a total population of about 35 million, of which 20.4 million reside in urban areas (Haut Commissariat au Plan, 2015). The climate differs by region: the coastal areas enjoy a temperate climate, while the south and east are desert. Most of the people reside in rural areas, where the water supply is mainly from wells; 64% of the rural population and 96% of the urban population have access to clean drinking water (El Jaoudi, 2014).

The most important source of fluorine in Morocco is fluorite deposits, which have been known since 1932. Morocco also has large deposits of phosphates, which are important sources of fluoride (Haikel, 1989). The exploration and transformation of these deposits release fluoride into the atmosphere. Water, soil and plants in the phosphate-rich areas also contain high levels of fluoride. Dental fluorosis is rampant in these phosphate-rich areas of the country (Haikel, 1986).

Tea is an important source of fluoride. Citizens consume it from an early age, especially in rural areas; 98.4% of Moroccan households consume tea. The average consumption is 4.6 glasses per person per day (Institut National de l'Administration Sanitaire).

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Figure 1: Map of Morocco

At the national level, the prevalence of moderate and severe underweight is 3.1%. It was 10.7% in 2003-2004 (Population and Family Health Survey EPSF 2003/2004 and 2011). Children living in urban areas are less affected by underweight when compared to those living in rural areas (1.7% vs 4.3%). Children from the lowest socioeconomic level are more affected by underweight than children from the highest socioeconomic level (6.7% vs 1.1%).

Pollution is a big problem in Morocco. Many factories have sprung up on the periphery of large cities, resulting from the government's industrialization policy. While this policy has created jobs, the pollution that the industries create is a problem, as laws and regulations on pollution control are poorly enforced (Nejjari, 2000). The polluting industries include thermal power plants, refineries, chemical industries, steel mills, and rubber, glass and plastic industries. The Casa-Airpol study revealed significant relationships between the level of air pollution, measured by the content of fine particles in the "black smoke," and mortality, asthma attacks, and respiratory infections in children (Casa Airpol, 2000).

Timing and Sequence of Emergence of Permanent Dentition

There are no data on the timing and sequence of emergence of the primary dentition in Morocco. Studies on emergence of permanent dentition span a period of 20 years (Lautrou, 1980; Basigny, 1983). Sabour (1987) studied the emergence of the permanent dentition in 175 Moroccan children aged 6 to 12 years. The percentage frequencies of permanent teeth were calculated for each child. Only the tooth whose percentage frequency in the oral cavity was greater than 50% was identified as emerged for the age considered. The authors determined that the age and sequence of emergence were:

- At 6 years: the first permanent molar and mandibular central incisor
- At 7 years: the maxillary central incisor and lateral mandibular incisor
- At 8 years: the maxillary lateral incisor
- At 10 years: the first premolar
- At 11 years: the canine and second permanent molar
- At 12 years: the second permanent molar

The emergence of permanent teeth happens in two phases. The first phase corresponds to the emergence of the first permanent molars and incisors. The second phase corresponds to the emergence of the canines, premolars and second permanent molars. Tooth emergence was earlier for the mandibular teeth than the maxillary teeth, and earlier in girls than in boys. The earlier emergence of the permanent dentition for girls was most pronounced at the age of 11 years. Tables 1, 2 and 3 highlight the percentage frequency of emergence of the permanent dentition.

Developmental Hard Dental-Tissue Anomalies

Anomalies of number: Two studies were conducted at the Casablanca Dental Consultations and Treatment Center to determine the prevalence of hyperdontia in Morocco. The first study was conducted by Hamza (2000). The data were collected in the Pediatric Dentistry Department between May 1995 and January 2001. All the children seen in the clinic during this period were reviewed. The study found 66 supernumerary teeth and/or odontomes in the oral cavity of 50 children. The second study was conducted by Adali

Table 1. Frequency of emerged permanent teeth for girls and boys aged 6 years

Tooth type	Girls %	Total %	Boys %		Tooth type	Girls %	Total %	Boys %
Right upper central incisor	40	28	20	MAXILLA	Left upper central incisor	40	28	20
Right upper lateral incisor	0	0	0		Left upper lateral incisor	0	4	7
Right upper canine	0	0	0		Left upper canine	0	0	0
Right upper first premolar	0	0	0		Left upper first premolar	0	0	0
Right upper second premolar	0	0	0		Left upper second premolar	0	0	0
Right upper first molar	80	80	80		Left upper first molar	70	68	67
Right upper second molar	0	0	0		Left upper second molar	0	0	0
Right lower central incisor	70	76	80	MANDIBLE	Left lower central incisor	70	72	73
Right lower lateral incisor	40	28	20		Left lower lateral incisor	30	28	27
Right lower canine	0	0	0		Left lower canine	0	0	0
Right lower first premolar	0	0	0		Left lower first premolar	0	0	0
Right lower second premolar	0	0	0		Left lower second premolar	0	0	0
Right lower first molar	80	84	87		Left lower first molar	80	84	87
Right lower second molar	0	0	0		Left lower second molar	0	0	0

Table 2. Frequency of emerged permanent teeth for girls and boys aged 9 years

Tooth type	Girls %	Total %	Boys %		Tooth type	Girls %	Total %	Boys %
Right upper central incisor	100	100	100	MAXILLA	Left upper central incisor	100	100	100
Right upper lateral incisor	83	76	69		Left upper lateral incisor	75	80	85
Right upper canine	8	12	15		Left upper canine	17	16	15
Right upper first premolar	50	36	23		Left upper first premolar	50	28	8
Right upper second premolar	0	8	15		Left upper second premolar	0	8	15
Right upper first molar	100	100	100		Left upper first molar	100	100	100
Right upper second molar	0	4	8		Left upper second molar	0	4	8
Right lower central incisor	100	100	100	MANDIBLE	Left lower central incisor	100	96	92
Right lower lateral incisor	100	96	92		Left lower lateral incisor	100	96	92
Right lower canine	25	28	31		Left lower canine	17	20	23
Right lower first premolar	25	24	23		Left lower first premolar	33	32	31
Right lower second premolar	8	12	15		Left lower second premolar	17	16	15
Right lower first molar	100	100	100		Left lower first molar	100	100	100
Right lower second molar	0	4	15		Left lower second molar	0	4	8

Table 3. Frequency of emerged permanent teeth for girls and boys aged 12 years

Tooth type	Girls %	Total %	Boys %		Tooth type	Girls %	Total %	Boys %
Right upper central incisor	100	100	100	MAXILLA	Left upper central incisor	100	72	100
Right upper lateral incisor	100	92	100		Left upper lateral incisor	100	88	92
Right upper canine	100	88	85		Left upper canine	92	80	92
Right upper first premolar	100	96	100		Left upper first premolar	100	92	92
Right upper second premolar	100	92	85		Left upper second premolar	100	88	75
Right upper first molar	100	100	100		Left upper first molar	85	88	92
Right upper second molar	85	72	58		Left upper second molar	92	80	67
Right lower central incisor	100	96	100	MANDIBLE	Left lower central incisor	100	96	100
Right lower lateral incisor	100	92	100		Left lower lateral incisor	100	96	100
Right lower canine	100	92	92		Left lower canine	100	92	100
Right lower first premolar	100	92	92		Left lower first premolar	100	88	92
Right lower second premolar	69	76	83		Left lower second premolar	62	68	75
Right lower first molar	92	96	100		Left lower first molar	92	96	100
Right lower second molar	92	80	67		Left lower second molar	92	80	67

(2010) in the Dentofacial Orthopedics Department of the same institution as the Hamza study, between September 2009 and January 2010. Adali reviewed 800 orthodontic patients and found supernumerary teeth in 27 patients – a prevalence of 3.7%. The results of the two studies are highlighted in Table 4.

Dental Transposition: A cross-sectional descriptive study was conducted on a population seen for dento-facial orthopedics at the Casablanca Dental Consultation and Treatment Center, a public dental reference center. This study reviewed the clinical and radiographic information of 547 patients seen between 2008 and 2011 (Bourzgui, 2012). Transposition was assessed using the 1995 Peck classification (Peck, 1995). The prevalence of transposition was 2%. Transposition was associated with dental agenesis: 23% of cases were associated with rhiziform incisors, 23% with primary tooth retention, and 82% with dental crowding (Bourzgui, 2012). Transposition was seen more (64%) in females, more often in the maxilla, and often unilaterally with a predilection for the left side of the jaw (Bourzgui, 2012). All cases of transposition involved the canines: 69% of the maxillary canines and maxillary lateral incisor and 31% of the maxillary canines and maxillary second premolar.

Dental Fluorosis: Dental fluorosis in Morocco is known as “darmous,” a term of Berber origin. Fluorosis occurs mainly in the areas where large quantities of phosphates are deposited and mined. Fluorosis affects humans and animals, with dental and bone disorders (Kandelman, 1989). The fluorine map of Morocco, shown in Figure 2 below, illustrates the fluoride content of water and the areas where fluorosis is endemic (Lahoussine, 2004).

Chronic fluorosis is present in the largest phosphatic region of Morocco, Khouribga, located south-east of Casablanca. Flourosis was first described by Velu (1932, 1933a), then by Charnot (1950a, 1950b, 1963), Becmeur (1951) and Jeanneret (1964). Chronic fluoride intoxication has been linked to the consumption of water containing more fluoride than the daily intake considered safe by the World Health Organization (El Jaoudi, 2014). Moller and Poulsen (1975), however, attributed fluorosis to phosphate dust emanating from factories in the region (in: Haikel, 1986).

Table 4. Characteristics of supernumerary teeth identified in the two studies conducted in Morocco

Variables	Hamza (2000)	Adali (2010)
Localization		
Maxillary	91%	88.9%
Mandibular	9%	11.1%
Degree of eruption		
Eruption	50%	25.9%
Inclusion	50%	74.1%
Location in the arch		
Incisor	98.5%	85.2%
Paramolar	1.5%	3.7%
Distomolar	0%	11.1%
Circumstances of discovery		
Reason for consultation	34%	-
Clinical Examination	26%	-
Fortuitous	40%	-
Type of teeth		
Eumorphic	24.2%	55.6%
Dysmorphic	75.8%	44.4%
Dentition		
Permanent tooth	97%	100%
Primary tooth	3%	0%
Complications		
Mechanical	90.9%	-
Tumoral	3%	-
Nervous	0%	-
None	6.1%	29.7%
Accidents of eruption		59.3%
Infectious problems		7.4%
Resorption of adjacent teeth		29.6%

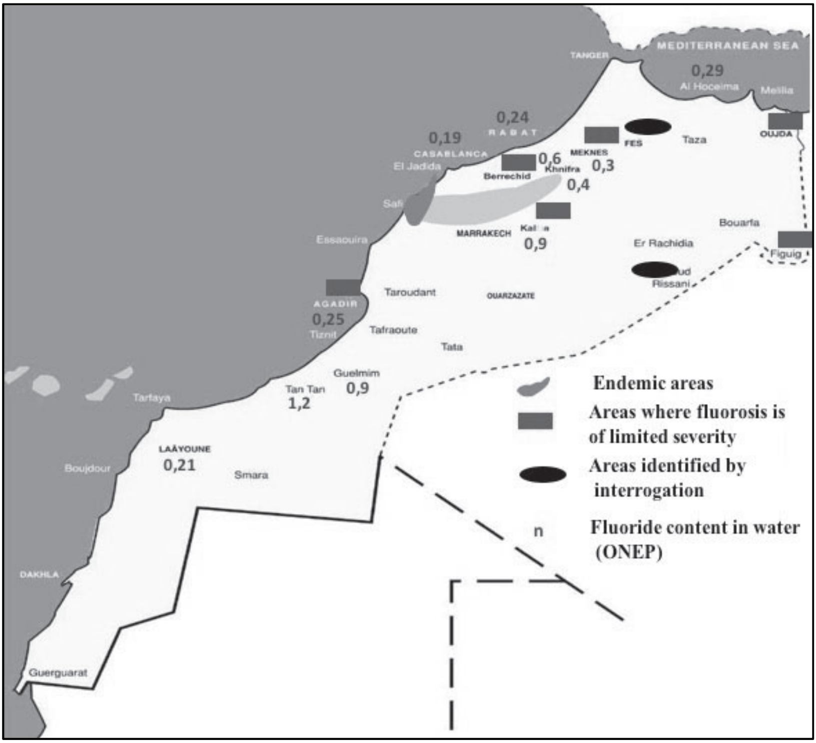

Figure 2. Mapping of fluoride in Morocco (1999)

Many other studies have been conducted in several regions of the country to determine the prevalence of fluorosis and etiological factors. All of the studies used the Dean's Index to determine the severity of fluorosis (Dean, 1946). One of these studies was a national survey published in the 1999 epidemiological bulletin. The prevalence of questionable, very mild and mild fluorosis was 13.4% of 12-year-olds and 14.4% of 15-year-olds. The prevalence of moderate to severe fluorosis was 0.6% in 12-year-olds and 1.2% in 15-year-olds (Bulletin épidémiologique, Royaume du Maroc, 2000). Figure 3 below graphically presents the prevalence of fluorosis by type.

Other studies reported a higher prevalence and severity of dental fluorosis in the phosphatic areas, such as the Khouribga, Bengrir, Safi and El Jadida regions, than in non-phosphatic areas (Haikel, 1989; Igroune, 1990). Table 5 provides a summary of the two studies.

Haikel et al (1989) studied 259 participants aged 7 to 15 years and 234 participants aged 16 to 20 years in the Khouribga region, a phosphatic region. They compared their results with those of study participants of the same age living in a non-phosphatic region, Beni Mellal, in central Morocco. The authors found that 90.24% of children and adolescents residing in the phosphatic region had questionable to severe fluorosis, with a preponderance for the moderate form of fluorosis, 33.98%. The community fluoride index was 2.28 for 7-15-year-olds and 2.11 for 16-20-year-olds. In Beni Mellal, however, few patients had fluorosis, and the community fluoride index was 0.02 (Haikel, 1989). No association was found between water consumption and fluorosis; the fluoride concentration in drinking water was 0.17 ppm in urban areas and 0.7 ppm in rural areas. Chronic exposure to dust particles of phosphatic origin was the main cause of fluorosis in Khouribga.

In Safi Province of Western Morocco on the Atlantic Ocean, Igroune (1990) assessed the status of fluorosis in children. He found that 7-year-old children had a fluorosis prevalence of 30.8%, while 12-year-olds had a prevalence of 36.66%. The community fluoride index for the 7-year-olds was 0.59 and for the 12-year-olds it was 0.79. Questionable, light and very light forms were predominant, and rural and peri-urban areas were most affected (Igroune, 1990). The fluoride content of the drinking water in the region (0.35 mg/l) could not account for the fluorosis observed. Other suggested etiological factors were protein deficiency, which could lead to enamel toxicity by the consumption of tea naturally rich in fluorine, and the proximity of phosphate processing plants causing industrial fluorosis (Igroune, 1990).

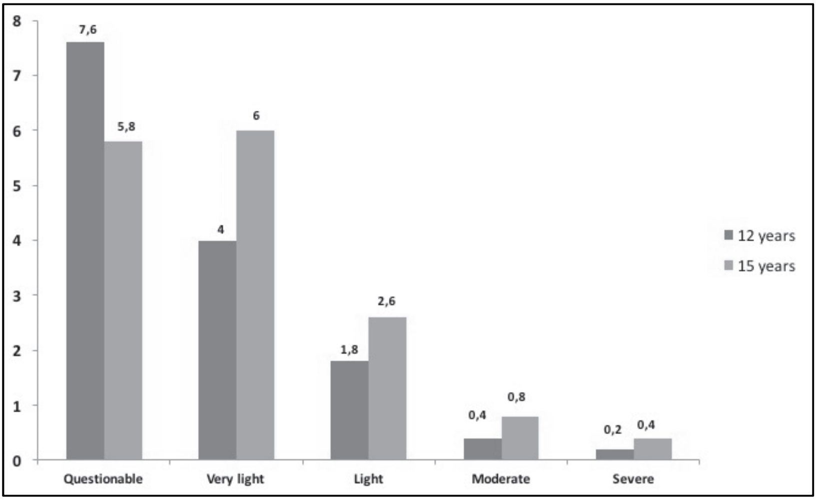

Figure 3: Prevalence of dental fluorosis by degree of affection and age in Morocco (1999)

Non-phosphate areas are not spared from dental fluorosis. Despite the efforts made by the state to improve the availability of pipe-borne water in Morocco, much of the rural population still consumes well water. A study conducted to determine the levels of fluoride ions in well water accessible to the Moroccan population and used as source of drinking water, showed that 53% of the wells had a fluoride content exceeding 0.7 mg/l, and 33% had more than 1.5 mg/l of fluoride (El Jaoudi, 2014).

Molar Incisor Hypomineralization: Benkirane et al (2017) conducted a cross-sectional study involving 1,077 children aged 7 to 10 years in public schools in Greater Casablanca and found a prevalence of molar incisor hypomineralization of 7.9%. This study provided the first data on molar incisor hypomineralization in Morocco. The incisor was involved in 92.94% of children. The large number of children with four molars affected probably explains the high number of incisor involvement found. There were no significant age and gender differences in the prevalence of the lesion. Children with molar incisor hypomineralization had a significantly

Table 5. Distribution of children with dental fluorosis residing in Khouribga and Safi regions by age and degree of fluorosis

Region and Age	Number of study participants	Prevalence of fluorosis (%)						
		No fluorosis	Questionable	Very light	Light	Moderate	Severe	Community fluoride index
Khouribga (1988)								
7-15 years	259	9.77	5.08	10.94	24.22	33.98	16.02	2.28
16-20 years	234	10.26	0.85	25.64	21.37	29.06	12.82	2.11
Safi (1990)								
7 years	240	69.20	13.80	8.80	5.40	2.90	00	0.59
12 years	240	63.33	18.33	7.08	3.33	3.33	4.58	0.79

higher prevalence of caries: 78.8% vs 33.5%. The diagnosis of molar incisor hypomineralization was based on the criteria proposed by the European Academy of Pediatric Dentistry (Werheijm, 2003). The defects recorded were mainly delimited opacities or post-eruptive enamel fractures involving only one side of the tooth. Table 6 highlights the results of the study.by Hammioui (2011) who tried to identify risk factors for molar incisor hypomineralization in Morocco. He examined 400 children aged 8 to 12 living in three regions with various levels of pollution. He tried to determine if exposure to dioxins was a risk factor for molar incisor hypomineralization. He found that 23.5% of children living at the Sidi Yahya Air Base near a pulp mill, 47.8% of children in downtown Sidi Yahya located 4 km from a dioxin-emitting factory, and 28.7% of children in Rabat, far from any industrial source of emission of environmental dioxins, had molar incisor hypomineralization. The children resident in the area exposed to pollution had significantly more molar incisor hypomineralization than those not exposed to pollution.

Table 6. Distribution of affected population by location and severity of molar incisor hypomineralization

	N	%
Number of first permanent molars affected		
4	72	84.7
3	8	9.4
2	4	4.7
1	1	1.2
Severity of molar incisor hypomineralization		
Light	44	52
Moderate	32	37
Severe	9	11
Affection of incisors		
With	79	92.94
Without	92	67.06

Table 7 provides a summary of findings from the study. Based on these results, it was concluded that exposure to dioxins is not safe for teeth, and its consequences are closely related to the time in the stage of development of the tooth when exposure occurs, and the toxic dose is received. Nevertheless, dioxin exposure is only one risk factor among many.

Table 7. Distribution of the population studied according to the prevalence and severity of MIH

Population	**Exposed Population**		**Unexposed**	
	Air Base	**Downtown Sidi Yahya**	**Rabat**	
	N (%)	N (%)	N (%)	
MIH prevalence	22 (23.4)	23 (12)	5(4.3)	**p<0.05**
MIH severity				
Mild	18 (81.8)	17 (73.9)	4 (80)	
Moderate	1 (4.6)	3 (13)	1(20)	
Severe	3 (13.6)	3 (13)	**p>0.05**	
			-	

Gaps and Recommendations

The Moroccan population has many developmental dental hard-tissue anomalies. However, only limited epidemiological studies have reported on these anomalies. There are, however, case reports of some of these anomalies (Benyahya, 1996; Bousfiha, 1997; Bousfiha, 2000; Bousfiha, 2002). A national epidemiological survey to determine the true prevalence of all forms of developmental dental hard-tissue anomalies in Morocco is needed because of the forensic and anthropological importance of these anomalies.

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NIGERIA

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Background Information on Nigeria

Figure 1 is a map showing the 36 states in the six geopolitical zones in the country – North West, North East, North Central, South South, South West and South East – and the Federal Capital Territory where the capital, Abuja, is located. Nigeria is the most populous black nation in the world. It is on the west coast of Africa, bordering Benin to the west, Chad and Cameroon to the east, and Niger to the north. Its coast in the south lies on the Gulf of Guinea in the Atlantic Ocean. The estimated population of Nigeria at the end of 2017 was 198 million (Population.gov.ng, 2018). Nigeria's population is young, with persons aged 0-24 accounting for more than 62% of the population (Nigerian Population Census, 2006). Lagos was once the capital of Nigeria, and it is the most populous city in Nigeria.

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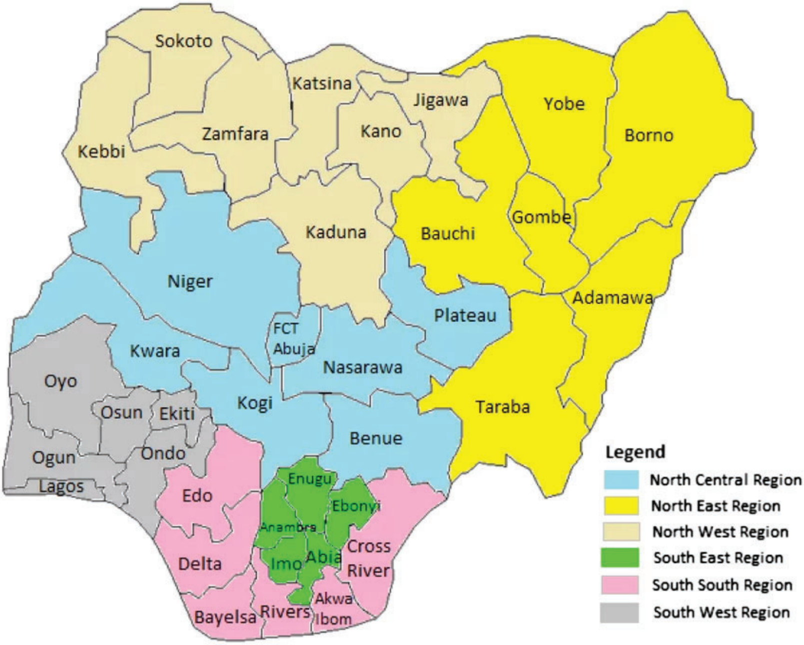

Figure 1: Map of Nigeria

At the end of 2017, Nigeria ranked 152 among the 188 countries on the Human Development Index (UNDP, 2017). In 2013, 35 million more Nigerians were living in extreme poverty than in 1990, and Nigeria was the only country of the 10 most populous countries in the world to have an increase in the number living in extreme poverty, defined as $1.90 or less per day (Kazeem, 2018). Though child nutrition has improved, about 11 million children under the age of five are still stunted; stunting is worse in the north-eastern and north-western parts of the country (UNICEF, 2018a).

Access to clean pipe-borne water is a challenge; only 9% of the water sources were from waterworks in 2009 (Akpata et al., 2009). About 70 million people lack access to safe drinking water (UNICEF, 2018b). Fluoride levels in water sources – rivers, streams, springs, shallow and deep wells, boreholes, ponds, rainwater, waterworks, and packaged water – are low in most parts of the country, 0.3 ppm or less in 62% of the local government areas. Fluoride concentrations were significantly higher in the North-Central geopolitical zone than in other zones (Akpata et al., 2009).

Akpata (2004) provided a summary of the level of ingestion of fluoride by children aged 1-3 years old through their drinking water; ingestion was higher in northern than in southern Nigeria.

The country is made up of over 350 ethnic groups. The largest ethnic group is the Hausas with an estimated population of 67 million. They make up approximately 25% of the Nigerian population and the majority are Muslims. The second largest group is the Yorubas making up approximately 21% of the population being a mix of Muslims and Christians. The third largest is the Igbos making up approximately 18% of the population and the majority are Christians (Worldatlas.com, 2019). Other major ethnic tribes are the Kanuris, Fulanis, Ijaws, Ibibios, and Tivs. The minority ethnic groups constitute about 12% of the population (Worldatlas.com, 2019).

Determination of age of individuals in Nigeria may also come with some challenges as birth registration is not a priority for many households (Ifesanya and Adeyemo, 2012). It is therefore important to find an accurate method for estimating the age of children in Nigeria. The Demirjian method was not an accurate measure of chronological age for children in a Southwestern Nigeria population. While the chronological and dental age of the children showed high correlation, there was a significant difference between the chronological and dental age among boys and a non-significant difference between the chronological and dental age among girls (Ifesanya and Adeyemo, 2012).

Timing and Sequence of Emergence of Primary Dentition

There are few studies (Enwonwu, 1973, Isiekwe, 1984; Folayan et al., 2007; Oziegbe et al., 2008) on the timing of emergence of primary dentition in Nigerian children. Oziegbe et al. (2008), in a study of 1,013 Nigerian children aged 4 to 36 months, observed that boys had emergence of all primary teeth earlier than girls, except for the primary first molars. Also, boys had earlier emergence of all teeth on the left side compared to those on the right side, a difference that was not observed in girls. In contrast, Folayan et al. (2007) and Enwonwu (1973) noticed no significant gender difference in the time of tooth emergence, nor did they observe any gender difference in the timing of emergence on the left and right sides. Emergence times of the lateral incisor, canine, and molars were similar for upper and lower teeth (Folayan et al., 2007).

None of the studies conducted in Nigeria determined the earliest time of emergence of primary teeth in children. The studies either determined the percentage of children who have emergence of the different primary teeth (Enwonwu, 1973, Isiekwe, 1984), or determined the average times of eruption for various teeth, using the probit analysis (Folayan et al., 2007; Oziegbe et al., 2008). Isiekwe (1984), however, reported that some boys had teeth in their mouth at five months of age.

Table 1 shows the age of emergence of the primary teeth determined by Folayan et al. (2007) and Oziegbe et al. (2008). Oziegbe et al. (2008) reported an earlier time of emergence of all the primary teeth except for the maxillary second molar than that reported by Folayan et al. (2007). Data for both studies were collected in the same community, and the same methodology was used for computing the age of tooth emergence. The reason for the differences observed was therefore not easily discernable; the only plausible explanation was that the data analyzed by Oziegbe et al. (2008) were collected ten years after those analyzed by Folayan et al. (2007), during which time the nutritional status of the population could have improved. Several studies (Infante and Owen, 1973; Haddad and Correa, 2005; Holman and Yamguchi, 2005) have reported that emergence of teeth is affected by nutritional status with emergence occurring earlier in children who have a better nutritional status. The results of a study by Enwonwu (1973) point to the validity of this proposal, as he showed that about 84% of children with high socioeconomic status, aged 4 to 6 months, had emergence of their mandibular central incisors, whereas there was 15% emergence among children with low socioeconomic status. Oziegbe et al. (2008) also observed more tooth emergence in children with high socioeconomic status than in children with low socioeconomic status of the same age. Folayan et al. (2007) were, however, unable to show an impact of socioeconomic status on the timing of tooth emergence.

The duration and form of breastfeeding – whether a child was exclusively breastfed or not – have no impact on the timing of emergence of the first tooth (Folayan and Sowole, 2013), the timing of the teeth that emerge within the first 12 months of life (Folayan, Oziegbe and Esan, 2010), or on the timing of emergence of the primary dentition (Folayan et al., 2007). In contrast, Oziegbe et al. (2010) observed that exclusively breastfed children had significantly earlier emergence of the central incisors and primary tooth emergence completed earlier than in those who were partially breastfed. Children who were taller had more teeth than children who were shorter for the same age (Oziegbe et al., 2008).

Table I. Mean age (months) times of eruption of primary teeth

	Oziegbe et al. (2008)				Folayan et al. (2007)			
	Boys		Girls		Boys		Girls	
Maxilla	**Age**	**SD**	**Age**	**SD**	**Age**	**SD**	**Age**	**SD**
Central incisor	9.29	1.92	10.06	2.54	10.37	2.30	10.45	3.33
Lateral incisor	11.98	3.27	12.94	4.01	12.67	3.19	13.18	3.73
Canine	17.82	4.03	18.27	4.16	19.35	3.63	19.54	4.31
First molar	16.03	3.04	15.99	2.88	16.58	2.75	16.34	3.23
Second molar	26.11	5.66	26.11	5.04	24.70	4.28	25.61	5.46
Mandible								
Central incisor	7.55	1.80	7.88	2.48	7.86	2.49	8.38	2.97
Lateral incisor	12.42	3.61	12.98	2.99	12.92	3.04	13.42	3.63
Canine	18.19	4.03	18.77	3.98	19.92	3.83	19.69	4.16
First molar	16.27	3.06	16.00	3.17	16.57	2.83	16.08	3.04
Second molar	24.13	5.55	24.20	4.67	24.52	4.21	25.22	4.97

The sequences of eruption for boys and girls are the same (Oziegbe et al., 2008).

$I_1I^1\ I^2I_2M^1M_1\ C^1C_1\ M_2M^2$ – Boys
$I_1I^1\ I^2I_2M^1M_1\ C^1C_1\ M_2M^2$ – Girls

These findings are similar to those of Folayan et al. (2007), except that researchers found that, in girls, the mandibular first molar erupts earlier than the maxillary first molar:

$I_1I^1\ I^2I_2M^1M_1\ C^1C_1\ M_2M^2$ – Boys
$I_1I^1\ I^2I_2M_1\ M^1\ C^1C_1M_2M^2$ – Girls

Timing and Sequence of Emergence of Permanent Dentition

Few studies have examined the time of emergence of the permanent teeth in Nigerian children (Akpata, 1971; Denloye, 2008; Oziegbe, Esan and Oyedele, 2014). Two of these studies (Akpata, 1971; Oziegbe, Esan and Oyedele, 2014) assessed the sequence and timing of emergence of all the permanent teeth, excluding the third molar, while the third study (Denloye, 2008) examined the sequence of emergence of the first permanent teeth.

Table 2 highlights the results of the two studies on the time of emergence of the permanent teeth in Nigeria conducted in Southwestern Nigeria. There is much more variation in the timing of eruption of permanent teeth than of the primary dentition. Oziegbe, Esan and Oyedele (2014) reported earlier mean times of eruption for most of the teeth compared with those reported by Akpata (1971) forty years earlier. Girls had an earlier time of emergence than boys, and the mandibular first central incisor was the earliest to emerge (Oziegbe, Esan and Oyedele, 2014). The method of determining the age of eruption for the two studies differed; Akpata (1971) used a graph of age versus the percentage of children with eruption of the tooth on a probability paper to determine mean times of eruption, whereas Oziegbe, Esan and Oyedele (2014) used probit analysis. Akpata (1971) observed that girls had an earlier time of tooth emergence than boys for all the teeth, except the mandibular lateral incisors. Similarly, Oziegbe, Esan and Oyedele (2014) reported that girls had significant earlier mean times of emergence of all the teeth than boys, except the mandibular central incisor.

Akpata (1971) reported no significant tendency towards emergence on the left side compared with that on the right side of the jaw. However, Oziegbe, Esan and Oyedele (2014) observed earlier tooth emergence on the right than on the left side in the maxilla in both sexes, whereas the reverse was the case in the mandible. This bilateral difference was significant only for the maxillary canine in girls.

The reported sequence of eruption differed between researchers. Denloye (2008) and Oziegbe, Esan and Oyedele (2014) reported that the mandibular central incisor emerges before the mandibular first molar in both sexes, as shown below.

$I_1M_1M^1\ I^1I_2I^2\ P^1P_1\ C_1\ P_2\ C^1\ P^2\ M_2M^2$ – Boys
$I_1M_1M^1\ I^1I_2I^2\ C_1\ P^1P_1\ C^1\ P_2P^2\ M_2M^2$ – Girls

Table 2. Mean age (years) times of eruption of permanent teeth

	Oziegbe, Esan and Oyedele (2014)				Akpata (1971)			
	Boys		Girls		Boys		Girls	
Maxilla	**Age**	**SD**	**Age**	**SD**	**Age**	**SD**	**Age**	**SD**
Central incisor	6.89	1.15	6.45	1.00	7.5	1.1	7.1	1.1
Lateral incisor	8.05	1.16	7.68	1.39	8.3	1.0	8.0	1.1
Canine	10.96	1.29	10.45	1.33	11.0	1.2	10.2	1.5
First premolar	10.25	1.39	9.76	1.39	10.6	1.2	10.1	1.3
Second premolar	11.08	1.45	10.75	1.39	11.1	1.5	10.3	1.3
First molar	6.15	0.93	5.95	0.97	6.3	0.9	5.8	1.3
Second molar	12.01	1.37	11.61	1.21	11.8	1.4	11.4	1.4
Mandible								
Central incisor	5.52	0.89	5.43	0.83	6.3	1.3	5.8	1.1
Lateral incisor	7.01	1.09	6.58	1.43	7.3	1.1	7.3	1.2
Canine	10.33	1.74	9.65	1.31	10.6	1.5	9.9	1.4
First premolar	10.29	1.29	9.80	1.21	10.7	1.3	9.9	1.0
Second premolar	10.85	1.49	10.56	1.27	10.9	1.2	10.6	1.4
First molar	5.78	1.29	5.59	1.06	6.0	0.9	5.8	1.3
Second molar	11.58	1.36	11.25	1.16	11.3	1.1	10.9	0.9

In contrast, Akpata (1971) reported that both teeth erupted in girls at the same time, whereas in the boys the mandibular first molar preceded the mandibular central incisor, as shown below.

M_1 (I_1 M^1) I_2 I^1 I^2 (C_1 P^1) P_1 P_2 C^1 P^2 M_2M^2 – Boys
(I_1 M_1M^1) I^1 I_2I^2 (C_1 P_1) P^1 C^1 P^2P^2 M_2M^2 – Girls

Orenuga, da Costa and Dolapo (2011) also studied crown development of the third molar of residents in South West Nigeria, using panoramic radiographs as described by Gravely (1965). Third molar crown development was observed as early as 5 years, a time earlier than that observed in Caucasians. The study also found that by the age of 6 years, 26% of third molars were in stage 1 of crown development, and 13% were at stage 5 of development. Also, by the age of 12.5 years, 50% of third molars were in stage 5 of crown development.

Developmental Dental Hard-tissue Anomalies

Most of the studies on dental hard-tissue anomalies were conducted in South West Nigeria. The studies provided information on the prevalence, predisposing factors and complications associated with developmental dental hard-tissue anomalies relating to tooth number, shape, size, structure and location. All the studies were based on the clinical detection of dental anomalies.

Temilola et al. (2014) conducted a household-based survey on dental anomalies in one of the 774 local government areas in Nigeria. The town where the study was conducted was in a suburban area not representative of the country. Their study was, however, the only community-based population survey on dental anomalies. It was a comprehensive assessment of all forms of developmental dental hard-tissue anomalies in the primary and permanent dentition of 1,036 children of 12 years and below. The authors reported a prevalence of 26.6% for developmental dental hard-tissue anomalies. Of these, 23.8% had one anomaly, 2.5% had two anomalies, and 0.3% had more than two anomalies. More anomalies were seen in permanent than in primary dentition. Anomalies of tooth structure were significantly more prevalent than anomalies of tooth size, tooth shape, and tooth number. There was no significant sex difference in the prevalence of the developmental dental hard-tissue anomalies, except for macrodontia; significantly more males than females had macrodontia. Also, there was no significant difference in the prevalence of dental hard-tissue anomalies based on socioeconomic status, except for macrodontia; more children of high socioeconomic status had macrodontia. Dens evaginatus, peg-shaped lateral, macrodontia, and talon cusp were more prevalent in permanent dentition. Also, dens evaginatus, peg-shaped lateral and macrodontia were more prevalent in the maxilla.

Popoola, Onyejaka and Folayan (2017) conducted a school-based study of the prevalence of developmental dental hard-tissue anomalies in the permanent dentition. They recruited 1,565 12-15-year-old children attending schools in two of the 36 States in Nigeria. They reported a lower prevalence of developmental dental hard-tissue anomalies – 4.2% – when compared with the report by Temilola et al. (2014). None of the children had two or more developmental dental hard-tissue anomalies. There were no significant age, sex or socioeconomic status differences in the proportion of children who had or did not have the anomalies.

Table 3 is a summary of the prevalence of the developmental dental hard-tissue anomalies observed by Adeniji (1997), Temilola et al. (2014) and Popoola, Onyejaka and Folayan (2017). The three studies used the same criteria for assessment of the anomalies. The prevalence of dental anomalies for the permanent dentition was recalculated for the study by Popoola, Onyejaka and Folayan (2017). Consistently, the three studies showed that enamel hypoplasia was the most prevalent developmental dental hard-tissue anomaly, although the figure reported by Popoola, Onyejaka and Folayan (2017) was much lower than those of the other studies. Adeniji (1997) and Temilola et al. (2014) reported figures in the mixed dentition, whereas Popoola, Onyejaka and Folayan (2017) reported figures in the permanent dentition. The findings from the studies may imply that enamel hypoplasia could be a major problem in the primary dentition.

Developmental Defects of Enamel

Ibiyemi et al. (2018) conducted a study on the developmental defects of the enamel in 8-year-old primary school children in rural and urban areas of Oyo State, Nigeria. The prevalence of developmental defects of enamel was 61.2%, of which 17.5% had one defect and 82.5% had two or more defects. Koleoso (2004) also identified 16.0% of 12-year-old school children in Lagos State with enamel opacities, 2.5% with enamel mutilation and 21.5% with tetracycline stain (Koleoso, 2004).

Enamel Hypoplasia: This is defined as a deficiency of enamel formation and may be expressed as pits, grooves or generalized hypoplasia (Slayton et al., 2001). Enamel hypoplasia is the most prevalent lesion in both the primary and permanent dentition. The prevalence reported in school-based studies ranged from 4% in primary dentition for in-school pre-school children (Adenubi, 1980), 6.2% of 8-year-old children (Ibiyemi et al., 2018), 7% of 12-year-old school students (Koleoso, 2004), 7.9% in 6-16-

Table 3. Prevalence of developmental dental hard-tissue anomalies in the primary and permanent dentition in Nigeria

Type of developmental dental hard-tissue anomaly	Prevalence in the mixed dentition Adeniji (1997)	Prevalence in the mixed dentition Temilola et al. (2014)	Prevalence in the permanent dentition Popoola, Onyekaja and Folayan (2017)
Enamel hypoplasia	11.3%	16.1%	2.2%
Dens evaginatus	-	6.4%	0.06%
Macrodontia	2.3%	2.0%	0.0%
Peg-shaped lateral	1.7%	1.5%	-
Microdontia	1.9%	1.4%	1.7%
Supernumerary	0.05%	0.4%	0.0%
Fusion/Gemination	0.2%/0.05%	0.4%	0.06%
Supplemental	-	0.3%	-
Talon cusp	0.05%	0.3%	0.06%
Mesiodens	-	0.1%	-
Dens Invaginatus	-	0.1%	0.06%
Transposition	-	0.1%	0.0%
Notched incisor	0.1%	0.1%	0.0%
Hypodontia	0.4%	0.0%	0.0%

year-old school children in Southwest Nigeria (Folaya et al., 2018), 11.22% of 4-16□year□old school children (Orenuga and Odukoya, 2010), and 11.7% of school children aged 10 to 19 years (Sawyer et al., 1984). Also, 0.9% of 8-year-old children (Ibiyemi et al., 2018) had a combination of enamel hypoplasia with demarcated opacities.

The reported prevalence of enamel hypoplasia was higher in sub-urban (Temilola et al., 2014) and rural areas (Ibiyemi et al., 2018) than in cosmopolitan areas. More female children and more children with middle socioeconomic status were likely to have enamel hypoplasia (Popoola, Onyejaka and Folayan, 2017). This difference may be related to the increased risk for chronic or acute malnutrition (Lukacs, 1991; Kanchanakamol et al., 1996), bacterial and viral diseases (Arrow, 2009; Guergolette et al., 2009), and very low birth-weight (Seow, 1997) disorders, which are more prevalent in sub-urban and rural areas. A comparison of study results is, however, difficult because of the difference in terminologies and diagnostic criteria for enamel hypoplasia used by the different studies.

Molar incisor hypomineralization: Most of the studies on molar incisor hypomineralization in Nigeria were conducted in one of the 774 local government areas: Ile-Ife, a sub-urban area. The reported prevalence of molar incisor hypomineralization in the permanent dentition was 17.7% in a school-based survey (Oyedele et al., 2015) and 9.7% in a population-based survey (Temilola, Folayan and Oyedele, 2015). The prevalence in the primary dentition was 4.6% in a population-based survey (Temilola, Folayan and Oyedele, 2015) and 5.8% in a school-based survey (Oyedele et al., 2015). There were no associations between the lesion, sex and socioeconomic status in all the studies.

A study on molar incisor hypomineralization conducted in Southwest Nigeria included populations recruited from Ile-Ife - a sub-urban area - and Ibadan – an urban area. The prevalence of molar incisor hypomineralization in 6-16 year olds recruited from these two population was 2.9%. The prevalence was higher in 6-9 year olds than other age groups (p=0.001), and higher in those with high socioeconomic status when compared with those with middle and low socioeconomic status (p=0.05). Molar incisor hypomineralization did not affect the quality of life of person affected (Folayan et al., 2018).

Also, 34.8% of children had co-morbidities associated with molar incisor hypomineralization in both the primary and permanent dentition (Oyedele et al., 2015), and 77.8 % of children with lesions in their primary dentition also had their permanent dentition affected (Oyedele et al., 2015). Molar incisor hypomineralization and enamel hypoplasia co-exist in 1.0% of the primary dentition and 0.08% of the permanent dentition (Temilola and Folayan, 2015). The identified precipitating environmental factors were prolonged use of antibiotics, early childhood illnesses, prenatal maternal ill health, and long duration of breastfeeding (Oyedele, 2015). The possible role of genetics in the etiology of molar incisor hypomineralization was also noted (Oyedele, 2015).

Fluorosis: The prevalence of dental fluorosis in Nigeria ranged from 13% to 51% in 12□15□year□old children living in areas with 0.59□0.75 ppm fluoride water content and 0□0.4 ppm fluoride water content, respectively

(Ibiyemi et al., 2018). Dental fluorosis is almost endemic in Northern Nigeria, resulting from the high fluoride content of the drinking water (Akpata, 2004). In Plateau State, one of the Northern States, the prevalence was 12.9% in 12-15-year-old children; the prevalence is significantly higher in the high-altitude areas than in the low altitude ones – 22.2% vs. 3.5% (Akosu, Zoakah and Chirdan, 2009). A prior survey in the same study location determined the prevalence of fluorosis as 26.1%, with 20.6% being mild and 5.5% severe.

In Southern Nigeria, Ibiyemi et al. (2018) reported that the prevalence ranged from 5.1% in the urban lower fluoride area to 82.3% in the rural higher fluoride area of Oyo State, using the Thylstrup and Fejerskov Index. A prior study in Oyo State using the same index reported a prevalence of fluorosis of 11.4% for 12-14-year-old school children (Ajayi et al., 2012). Koleoso (2004) reported a prevalence of fluorosis of 36.5% in Lagos State using Dean's Index – 29% with very mild fluorosis and 7.5% with mild fluorosis. In Enugu, located in South east Nigeria, the prevalence was 11.3%, with 82.2% of those with fluorosis having a very mild score and 6.7% having a moderate score. The study in Enugu used Dean's Index (Okoye, 2009).

Anomalies of Shape

Peg-shaped lateral: This was defined as any upper lateral incisor with a reduction in its mesio-distal size in a gingivo-incisal direction. Table 3 above shows the prevalence of peg-shaped laterals determined by Temilola et al. (2014) – 1.5%. Prior studies by Sawyer et al. (1984), Adeniji (1997), and Onyeaso (2006) reported a prevalence of 1.5%, 1.7% and 1.4%, respectively. The prevalence was higher (2.3%) in a study using orthopanthomographs of orthodontic patients (Ucheonye and Akeredolu, 2010). A prevalence of 14% was reported in children with Down syndrome (Oredugba, 2007).

Significantly more cases of peg-shaped laterals were identified in the permanent than in the primary dentition and in the maxilla than in the mandible. No difference was found in the prevalence on the left and right side of the face (Temilola et al., 2014) and no sex predilection (Ucheonye and Akeredolu, 2010; Temilola et al., 2014).

Talon cusp: It is a prominent accessory cusp-like structure projecting from the cingulum area or cement-enamel junction of the maxillary or mandibular teeth in both primary and permanent dentition (Peker and Alkurt, 2009). The prevalence is extremely low – less than 0.4% (Temilola et al., 2014; Popoola, Onyejaka and Folayan, 2017), and it is seen only in the maxilla and the permanent dentition (Temilola et al., 2014). There are a few case reports on the clinical management of talons cusps in Nigeria (Sanu, 2001; Oredugba and Orenuga, 1998), including an unusual case of talon cusp on the facial aspect of a mandibular central incisor (Oredugba, 2005) and a case involving all the four maxillary incisors (Oginni et al., 2001).

Dens evaginatus: Dens evaginatus is defined as the presence of an accessory cusp whose morphology makes it an abnormal tubercle (Levitan and Himel, 2006). Temilola et al. (2014) identified dens evaginatus as the second most prevalent lesion in mixed dentition, with a prevalence of 6.4%. The prevalence reported by Popoola et al. (2017) is much lower – 0.06%. Dens evaginatus is present in both the primary and permanent dentition, with a higher tooth-level prevalence in the permanent dentition, more prevalent in the maxilla than in the mandible, and with no antimeres (Temilola et al., 2014).

Dens invaginatus: Dens invaginatus is a developmental anomaly resulting in a deepening or invagination of the enamel organ into the dental papilla prior to calcification of the dental tissues (Hülsmann 1997). Dens invaginatus is a rare lesion, with only one case reported in a study involving 1,036 children aged 4 months to 12 years (Temilola et al., 2014). Popoola, Onyejaka and Folayan (2017) also identified one case in a study of 1,565 school children aged 12 to 15 years. There is a case report on the management of the lesion affecting the maxillary incisors (Oderinu, Adegbulugbe and Agbaje, 2007).

Cusp of Carabelli: This is a morphological anomaly of the crown, usually seen on the mesiopalatal surface of the maxillary first permanent molars. Falomo (2002) screened for the cusp of Carabelli in 2,604 Nigerians and reported a prevalence of 17.43%. Of these, 70.71% presented bilaterally and 25.99% presented unilaterally. Simultaneous involvement of the maxillary first and second molars occurred in 1.98% of cases. There was no sexual dimorphism, but teeth varied in size.

Taurodontism: This is a malformation of multi-rooted teeth characterized by an abnormally large pulp chamber and abnormally short roots (Sote and Ogunkola, 2009). The prevalence of taurodontism in children in Nigeria is unknown, but evidence points to a high prevalence in the population. Yemitan and Adediran (2015) screened 97 orthodontic patients – 41 males and 56 females – for taurodontism, using orthopantomograms. Results showed that 33% of the patients had one or more taurodonts, with no significant gender differences. Unilateral taurodontism was more prevalent than bilateral taurodontism. There was no significant preference for the left or right side. The most prevalent taurodont was hypotaurodonts (14.7%), followed by mesotaurodonts (4%) and hypertaurodonts (0.4%). Sote and Ogunkola reported a case in which the second permanent molars were taurodont; the child had an unusual presentation of taurodontism on a tooth with the cusp of Carabelli.

Anomalies of Size

Tooth size is affected by factors like sex, race, diet and environment. Adeyemi and Isiekwe (2003) determined the size of the teeth for a population of male and female Yoruba adolescents aged 13-15 years resident in Ibadan, Nigeria. The mean sizes of each of the permanent teeth exclusive of the third molar, are highlighted in Table 4. The mean sizes of the permanent teeth were significantly larger for males than for females in both the maxilla and the mandible except for the second mandibular molars (Adeyemi and Isiekwe, 2003a). In males, the variability in tooth size was least for the first molar in both the mandible and maxilla, and most for the canine in the maxilla and the second premolar in the mandible (Adeyemi and Isiekwe, 2003b). In females, the variability in tooth size in the maxilla was least for the canine and most for the lateral incisor. In the mandible, it was least for the first permanent molar and most for the second permanent molar (Adeyemi and Isiekwe, 2003b). There was also no difference in tooth size when the left side of the face was compared to the right side except for the maxillary second premolar and the mandibular canines in females (Adeyemi and Isiekwe, 2003c).

There were no significant differences in tooth sizes for Nigerians and black Americans (Adeyemi and Isiekwe, 2003d). The permanent tooth sizes of Nigerians were however, significantly larger than those of the Britons except for the mandibular central incisors and maxillary canines (Otuyemi and Noar, 1996). Mark (1981) also found the maxillary central incisor widths of Nigerians significantly larger than those of the Britons.

Table 4. Permanent tooth sizes for male and female adolescents, resident in Ibadan, Nigeria (Adeyemi and Isiekwe, 2003a)

Tooth	Mean tooth size for the maxilla in mm			
	Male		Female	
	Mean tooth size	Range	Mean tooth size	Range
Central incisor	9.67	7.5-11.0	9.32	7.5-11.0
Lateral incisor	7.72	6.0-9.5	7.49	6.0-9.5
Canine	8.26	6.5-10.0	7.92	7.0-9.5
First premolar	7.85	6.5-9.0	7.61	6.0-9.0
Second premolar	7.14	6.0-9.0	7.03	5.5-8.5
First molar	11.05	9.5-13.0	10.61	7.0-13.5
Second molar	9.96	8.5-12.0	9.64	8.0-11.5
	Mean tooth size for the mandible in mm			
Central incisor	5.96	5.0-7.0	5.86	5.0-7.0
Lateral incisor	6.52	5.5-7.5	6.44	5.5.-7.5
Canine	7.67	6.0-8.5	7.33	6.0-9.5
First premolar	7.86	6.5-9.0	7.71	6.0-9.0
Second premolar	7.72	6.0-9.0	7.63	6.0-8.5
First molar	11.71	8.0-13.5	11.67	9.0-13.0
Second molar	9.78	8.5-11.5	9.90	8.5-11.5

Microdontia: These are teeth that are smaller than usual (Bargale and Kiran, 2011). The studies that reported population prevalence data on microdontia based their assessment on visual examinations, which is not objective and can introduce reporting bias. The study by Popoola, Onyejaka and Folayan (2017) did not exclude peg- shaped incisors in its diagnosis of microdontia, whereas Adeniji (1997) and Temilola et al. (2014) made a distinction between the two phenomena. Despite these differences in diagnostic criteria, the prevalence of microdontia was similar; Popoola, Onyejaka and Folayan (2017) reported a prevalence of 1.7%. Temilola et al. (2014) reported a prevalence of 1.4%, and Adeniji (1997) reported a prevalence of 1.9%.

Macrodontia: These are teeth that are larger than usual (Canoglu et al., 2012). As with microdontia, the assessment of tooth size in the studies by Popoola, Onyejaka and Folayan (2017) and Temilola et al. (2014) were based on visual inspections, which could introduce bias. Temilola et al.

(2014) reported a prevalence of 2.0% with no antimeres, more cases in the maxilla than in the mandible, and no cases in the primary dentition. Popoola, Onyejaka and Folayan (2017) found no cases of macrodontia. Akande (1997) reported a case in the literature.

Gemination/Fusion: Geminations are anomalies that arise from an attempt at division of a single tooth germ by an invagination, which results in the incomplete formation of two teeth and a corresponding increase in the number of teeth in the dental arch (Bailit, 1975). Fusion is the union of two normally separated tooth buds, with the resultant formation of a joined tooth with a confluence of dentine (Garvey, Barry and Blake, 1999). Temilola et al. (2014) reported a prevalence of 0.4% for both lesions. The prevalence was higher in males and in those from high socioeconomic strata. Adeniji (1997) reported a prevalence of 0.05% and 0.2% for gemination and fusion, respectively. Popoola, Onyejaka and Folayan (2017) reported a lower prevalence (0.06%) for a combination of both lesions. Onyeaso and Onyeaso (2006), however, reported a higher prevalence (1.9%) in the permanent dentition in a population of school children.

Anomalies of Number

Hypodontia: This is the absence of a tooth or teeth, exclusive of the third molars (Gupta et al., 2011). Hypodontia is a rare phenomenon in Nigeria. Temilola et al. (2014) and Popoola, Onyejaka and Folayan (2017) reported a prevalence of 0.0% of hypodontia in their large population-based surveys. However, Adeniji (1997) reported a prevalence of 0.4%, and Onyeaso and Onyeaso (2006) reported a prevalence of 3.6% in the permanent teeth of surveyed school children. The prevalence is high, in children with Down syndrome – 63%. The teeth most affected were the maxillary and mandibular left third molars in 14% of the 86 children, followed by maxillary and mandibular right third molars (12%), the maxillary left lateral incisor (9%), and the maxillary right lateral incisor, mandibular left lateral incisor and canine missing in 7% respectively (Oredugba, 2007). There are multiple case reports on hypodontia involving the mandibular right canine (Dosumu, Adeyemi and Kolude, 2009) and associated with ectodermal dysplasia (Familusi et al., 1975; Denloye et al., 1996; Ogunrinde et al., 2012).

Hyperdontia: This could be a mesiodens, a supernumerary tooth or a supplemental tooth. A mesiodens is a supernumerary tooth present in the pre-maxilla between the two central incisors (Bailit, 1975). A supernumerary tooth is an additional tooth to the normal series (Reddy, Karpagavinayagam and Subbarao, 2008), while a supplemental tooth is an additional tooth to the normal series resembling the tooth with which it is associated (Salamaand Abdel-Megid, 1994). Popoola, Onyejaka and Folayan (2017) found no case of a supernumerary tooth in their survey of school children. On the other hand, Temilola et al. (2014) reported a prevalence of 0.1% of erupted mesiodens, 0.4% of erupted supernumerary teeth and 0.3% of erupted supplemental teeth. Supernumerary and supplemental teeth were found in both the primary and permanent dentition and in the maxilla and the mandible, with a predisposition for the right side of the jaw (Temilola et al., 2014). A rare case of erupted bilateral tuberculate maxillary supernumerary teeth in the region of the central incisor was reported by Eigbobo and Osagbemiro (2011).

Anomaly of Location

Tooth transposition: This is a positional interchange of two adjacent teeth (Peck, Peck and Attia, 1993). Temilola et al. (2014) reported two children with clinical transposition in the right side of the mandible. In a population of orthodontic patients, Umweni and Ojo (1997) reported a prevalence of 0.135%, involving the mandibular lateral incisors and canines, maxillary lateral incisors and canines, maxillary canines and premolars, and mandibular canine and central incisors in order of frequency. Another study by Onyeaso and Onyeaso (2006) found a prevalence of 0.6% of tooth transposition among 11-12 years old school children.

Gaps and Recommendation

A few comprehensive studies on the timing and sequence of tooth emergence and developmental dental hard-tissue anomalies have been conducted. However, none of these studies has a nationally representative sample. Study results on the prevalence of developmental dental hard-tissue anomalies generated from the same region within the country also vary, sometimes significantly. These findings highlight the need for a national survey, as the data generated from these surveys indicate that the timing of tooth emergence in Nigeria, and the prevalence of developmental dental hard-tissue anomalies, differ from those of other populations.

Also, in view of the major ethnic differences in the Nigerian population, it will be important to determine the most accurate method for estimating age; or develop a chart that appropriately estimates the age of the population(s) in Nigeria.

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PAKISTAN

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Background Information on Pakistan

Pakistan is the 9th most populous country in the world, with a population of about 152 million, 30% of which live below the poverty line, and only 55% have access to basic healthcare (Shah, Darby and Bauman, 2011). Geographically, Pakistan is the 33rd largest country in the world (Figure 1). It has a 1,046-kilometer coastline along the Arabian Sea and Gulf of Oman in the south and is bordered by India to the east, Afghanistan to the west, Iran to the southwest, and China in the far northeast. Pakistan was created in 1947 as an independent homeland for Indian Muslims (Jalal, 1997). It is an ethnically and linguistically diverse country, with a similarly diverse geography and wildlife. Pakistan is a federal parliamentary republican state comprised of four provinces: Punjab, Khyber Pakhtunkhwa, Sindh, and Balochistan (Khan, 2005) and four territories: the Federally Administered Tribal Areas, Islamabad Capital Territory, Gilgit–Baltistan, and Azad Kashmir. Its major ethnic groups in order of numerical size are: Punjabis, Pashtuns, Sindhis, Siddis, Saraikis, Muhajirs, Baloch, Hindkowans, Chitralis, Gujarati and smaller groups. Smaller ethnic groups, such as Kashmiris, Kalash, Burusho, Khowar, Hazara, Shina, Kalyu and Balti, are mainly found in the northern parts of the country.

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Figure 1: Map of Pakistan (Adopted from the Web)

Environmental conditions in Pakistan are poor. The air is polluted with industrial exhaust and waste materials, and there is poor access to sanitation facilities, disposal systems for solid waste, and safe drinking water, and poor public awareness about health and nutrition. The use of contaminated water and exposure to the polluted environment increase the risk of diseases such as diarrhea, dysentery, malaria, respiratory infections, influenza, and hepatitis. It is estimated that 45% of the population in Pakistan do not have access to health services, 40% do not have safe drinking water, and 53% are living without sanitation facilities (Haqueet al., 2006). Also, 20-30% of children of 1-5 years of age have had an episode of diarrhea during the previous two weeks (Islamabad, 2001). The average child may experience 5-12 episodes of diarrhea per year (Qureshi and Arif, 2001).

There has been almost six decades of access to fluoridated drinking water in communities that have access to piped water. Most water supplies are however low in fluoride content; 84% contain less than 0.7 ppm of fluoride (Ayyaz, Whelton and O'Mullane, 2002). Therefore, most of the population in Pakistan use alternative sources of fluoride to ensure the necessary intake for the control of dental caries.

Timing and Sequence of Emergence of Primary and Permanent Dentitions

Two studies describe the timing and sequence of emergence of the primary and permanent dentition in Pakistani children. Saleemi et al. (1994) found no significant differences in the timing of emergence of the primary dentition between Pakistani children and that in other countries. Also, no gender differences were found in the emergence of each primary tooth (Saleemi et al., 1994). Khan (2011) also assessed the time of emergence of the permanent teeth of Pakistani children and the effects of gender, types of school, height, weight and body mass index on emergence. He found that the time of emergence of the permanent teeth in Pakistani children is different in many respects, from that of other nationalities. Moreover, children who were tall had delayed emergence, irrespective of their weight. Those who were heavier had an earlier emergence time, irrespective of their height. No relationship was found between body mass index and tooth eruption time. Table 2 provides a summary of the mean emergence time of the permanent teeth in children from several countries, inclusive of Pakistan.

Developmental Dental Hard-tissue Anomalies

No epidemiological studies have been conducted on the Pakistani population to determine the prevalence of developmental dental hard-tissue anomalies. However, four studies determined the prevalence of some dental anomalies in orthodontic patients (Durrani et al., 2010; Khan et al., 2015; Majeed et al., 2014; Rasool et al., 2016).

Majeed et al. (2014) randomly selected 210 orthodontic patients' records and analyzed the radiographs for missing, impacted or supernumerary teeth. The prevalence of hypodontia, excluding third molars, was 3.38% and it was more common in males than in females. Missing teeth, inclusive of the third molar, were more common in females than in males. The prevalence of impacted teeth, exclusive of the third molar, was 8.57%.

The most common missing teeth are the upper right canine and the lower right second premolar. The prevalence of supernumerary teeth was 0.95%, and these were more common in males than in females.

Rasool et al. (2016) studied 150 orthodontic patients and reported that 59.3% of patients had dental anomalies. Durrani et al. (2010) analyzed 500 radiographic records of orthodontic patients to assess tooth agenesis, exclusive of third molars, and reported a prevalence of 9% for hypodontia. The study of 520 orthodontic patients by Khan et al. (2015) found a prevalence of dental anomalies of 16%; hypodontia was the most common dental anomaly, occurring in 37 (7.1%) patients. The maxillary lateral incisor was the most commonly missing tooth. Microdontia was the second most prevalent dental anomaly, occurring in 21 (4%) patients, with the maxillary lateral incisor being the most commonly affected tooth. A double tooth, a rare finding, was present in only 1 (0.19%) patient. Table 3 provides a summary of the findings on dental anomalies in Pakistan.

Table 2: Mean emergence time of the permanent teeth in children from Belgium, Finland, Ghana, Nigeria, USA, Australia, India, Iran and Pakistan (in years)

Teeth	Belgium (Leroy et al., 2003)		Finland (Virtanen et al., 1994)		Ghana (Houpt et al., 1967)		Nigeria (Akpata, 1971)		USA (Savara and Steen, 1978)		Australia (Diamanti and Townsend, 2003)		India (Shourie, 1946)		Iran (Moslemi, 2004)		Pakistan (Khan, 2011)	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Maxilla																		
Central incisor	7.1	6.9	6.8	6.8	6.2	6.0	7.5	7.1	7.2	7.2	7.4	7.2	6.9	7.2	6.7	7.5	7.5	7.5
Lateral incisor	8.2	7.9	8.1	7.6	7.4	7.2	8.3	8.0	8.3	8.2	8.6	8.2	7.9	7.5	8.4	8.8	8.45	8.3
Canine	11.5	10.9	11.3	10.8	9.9	9.5	11.0	10.2	11.5	11.0	11.8	11.2	9.9	10.8	11.8	12.1	10.9	10.7
1st Premolar	10.7	10.4	10.9	10.3	9.2	9.0	10.6	10.1	11.1	10.5	11.3	10.8	9.7	10.5	11.9	11.0	10.1	10.1
2nd Premolar	11.6	11.3	11.7	11.6	10.2	10.0	11.1	10.3	11.7	11.2	12.1	11.7	10.6	11.5	12.5	12.5	10.1	10.8
1st Molar	6.3	6.2	6.3	6.1	5	5.0	6.3	5.8	6.5	6.4	6.71	6.5	5.7	6.9	6.8	6.7	6.6	6.6
2nd Molar	12.2	11.9	12.4	11.9	10.9	10.9	11.8	11.4	12.2	12.1	12.7	12.3	11.6	11.9	12.6	12.5	11.6	12.0

Teeth	Belgium (Leroy et al., 2003)		Finland (Virtanen et al., 1994)		Ghana (Houpt et al., 1967)		Nigeria (Akpata, 1971)		USA (Savara and Steen, 1978)		Australia (Diamanti and Townsend, 2003)		India (Shourie, 1946)		Iran (Moslemi, 2004)		Pakistan (Khan, 2011)	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Mandible																		
Central incisor	6.3	6.1	6.0	5.9	5.2	5.1	6.2	5.8	6.3	6.1	6.6	6.3	7.0	7.2	6.0	6.5	6.7	7.0
Lateral incisor	7.4	7.1	7.1	6.8	6.2	6.3	7.3	7.3	7.5	7.2	7.8	7.4	7.8	7.5	7.3	7.9	8.4	7.8
Canine	10.6	9.7	10.5	9.7	9.4	8.9	10.6	9.9	10.7	9.9	11.0	10.1	10.8	10.5	9.7	10.2	11.8	9.9
1st Premolar	10.7	10.2	10.7	10.3	9.5	9.2	10.7	9.9	10.9	10.4	11.1	10.6	10.8	10.1	10.1	11.0	12.2	10.3
2nd Premolar	11.7	11.4	11.6	11.3	10.4	10.3	10.9	10.6	11.6	11.1	12.11	11.7	11.8	11.4	10.9	12.5	12.8	10.7
1st Molar	6.3	6.2	6.2	6.1	4.7	4.4	6.0	5.8	6.5	6.3	6.6	6.3	6.6	6.8	5.6	6.7	6.8	6.4
2nd Molar	11.8	11.5	12.0	11.6	10.5	10.5	11.3	10.9	12.0	11.8	12.1	11.8	12.3	11.6	11.3	12.4	12.9	11.3

M, male; F, female

Table 3: Prevalence of dental anomalies in orthodontic patients in Pakistan

Anomalies	Durrani et al., 2010	Khan et al., 2015	Majeed et al., 2014	Rasool et al., 2016
Third molar agenesis	-	-	2.85%	28%
Hypodontia	9%	7.10%	3.38%	3.3%
Hyperdontia	-	1.5%	-	
Impaction	-	-	8.57% except 3rd molar	17.7%
Supernumer- ary teeth	-	-	0.95%	4.1%
Microdontia	-	4%	-	1.3%
Macrodontia	-	2.10%	-	
Dilaceration	-	-	-	1.3%
Odontoma	-	-	-	2%
Transposition	-	0.38%	-	0.66%
Taurodontism	-	0.5%	-	-
Double tooth	-	0.19%	-	-

Gaps and Recommendations

The number of studies on the prevalence of developmental dental hard-tissue anomalies in Pakistan is limited. There are no studies on the etiological or predisposing factors of these lesions; neither are there studies on forms of dental anomalies beyond those of anomalies associated with tooth numbers. The few studies on dental anomalies have been limited to the permanent dentition; there are no data on the prevalence of developmental dental anomalies in primary dentition. Moreover, most of the studies have been conducted in only one of the four provinces in Pakistan – Karachi. A nationally representative cross-sectional study will be required to identify the prevalence of developmental dental hard-tissue anomalies in all of Pakistan. This information will help to identify racial differences in tooth-emergence patterns and the prevalence of developmental dental hard-tissue anomalies, which could form the basis for genetic studies that would benefit the country.

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PALESTINE

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Background Information on Palestine

The State of Palestine includes the areas of the West Bank of the River Jordan, East Jerusalem city, and the Gaza Strip on the Mediterranean coast. Palestine has a population of 2,935,368 on the West Bank and 1,881,135 on the Gaza strip (Palestinian Central Bureau of Statistics, 2016). In 1948, during the Palestinian crisis, more than 700,000 Palestinians - 85% of the Palestinian population - were forcefully displaced from their homes by Israeli forces to the West Bank, Gaza Strip, Jordan, Lebanon and Syria (Morris, 2001). In 1950, the United Nations Relief and Works Agency for Palestine Refugees intervened in the crisis and began providing education; healthcare; relief and social services; camp infrastructure and improvement; and microfinance and emergency assistance. This Agency remains the main healthcare provider in Palestine. The Palestinian territory has 27 refugee camps, 19 in the West Bank, and 8 in the Gaza Strip. The United Nations Relief and Works Agency has registered 4.7 million Palestinian refugees. About one-third of these still live in Palestinian refugee camps in the Gaza Strip and the West Bank; the rest have moved into towns and villages of the host population (World Health Organization, 2009).

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Figure 1. Map of Palestine (Wikimedia commons, 2015)

Palestine has a high growth rate (United Nations, 2009), with a 2.9% increase in the population for the year 2015 and a crude birth rate of 28.8/1000 for the same year (Palestinian Ministry of Health, 2015).

Palestine is considered a young society, with nearly 40% of the population (2.5 million) under 18 years of age (United Nations, 2009). Children in Palestine have been affected by the continued crisis in the region, made worse by the 6-day war of 1967 between Israel and Arab States. There has been a decline in infant and under-five-years mortality in the past two decades (United Nations, 2009; Central Bureau of Statistics, 2014).

The Palestinian population has a high prevalence of consanguineous marriages, with a reported prevalence of 44.3%. Consanguinity might be responsible for some of the nation's dental anomalies (Zlotogora, 1997).

Timing and Sequence of Emergence of Primary and Permanent Dentitions

There are no population-specific data about the time and sequence of eruption of primary and permanent teeth for the Palestinian population. The closest resemblance to the Caucasoid Arabs is the Jordanian population. One could therefore extrapolate the findings on the timing and sequence of emergence of the primary and permanent teeth studies in the Jordanian population for Palestine (Shaweesh, 2012; Al-Batayneh, Shaweesh and Alsoreeky, 2015). Also, no studies have been done to identify factors that may affect the timing of emergence of teeth in Palestinians.

Developmental Dental Hard-tissue Anomalies

Various dental anomalies are associated with defects in tooth development, which may be precipitated by hereditary, systematic, traumatic, or local factors. Numerous systems have been used to classify dental anomalies, and each has its merits. Often dental anomalies are classified in terms of abnormalities in the tooth number, size, shape, structure, and color (Casamassimo, Fields and McTigue, 2013). Unfortunately, no studies have evaluated the prevalence of developmental dental defects in the Palestinian population. Neither are there studies that assess possible predisposing factors associated with developmental dental hard-tissue anomalies.

Gaps and Recommendations

No studies have been conducted on the timing and sequence of emergence of the primary and permanent dentitions and related etiologic factors for eruption anomalies in Palestinians. There are also no studies on the prevalence and risk factors for developmental dental hard-tissue anomalies in this population. These kinds of data are urgently needed in view of their importance for pediatric dentistry and orthodontic patients' management, forensic investigations and anthropological research.

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Peru

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Background Information of Peru

Peru (or the Republic of Peru) is on the west coast of South America, extending from the Pacific Ocean to the Andes Mountains and to the Amazon Jungle. According to the census conducted in June 2017, the Peruvian population is estimated at 31 million people. Seventy-five per cent of the population live in urban areas, 25% in rural areas. Children under the age of five comprise 10% of the population (National Institute of Statistics and Informatics (INEI), Peru, 2017). The World Bank categorizes Peru's economy as upper-middle income, and it is the 39th largest economy in the world (World Bank statistics, 2018). The level of poverty in Peru is 28%, and the mortality rate in children is estimated to be 8% (INEI, Peru, 2018). Peru's capital is Lima, on the coast, where one-third of the population lives. The Peruvian population consists of various ethnic groups, of which 82% are indigenous and Mestizo.

Although poverty levels in Peru have decreased in the last 20 years, malnutrition is still a serious public health problem. In a study by Hernández Vásquez and Tapia Lopez (2017), 23% of Peruvian children under five years in 2010, and 18% in 2016, had chronic malnutrition. In a study done in 2011 in rural areas, 47% of the population have access to clean water, and 72% have access to sewage treatment (Ministry of Health. Peruvian Health Situation. Basic indicators 2011). These limitations likely have an impact on general health and may be a risk

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Figure 1. Map of Peru

factor for dental problems. Peru is a mining and volcanic country, which may increase children's exposure to metals.

Timing and Sequence of Emergence of Primary and Permanent Dentitions

Studies on the timing and sequence of dental eruption in Peruvian children are scarce and those that have been conducted are cross-sectional. Many have limited validity because of a small sample size. A prospective cohort study would be important to confirm the relationships between birth weight, weight-for-age, child malnutrition, and tooth emergence time or sequence in Peru.

Primary dentition: In a cross-sectional study of 86 18-29-month infants attending a public hospital in Lima, Jara and Rodríguez (2006) concluded that there was a significant relationship between primary tooth emergence and children's weight; children with low weight-for-age and low weight-for-height had a delayed emergence of primary teeth. Quispe (2016) obtained similar results in a cross-sectional study of 196 children younger than 20 months in a public hospital in Trujillo, in northern Peru. The author found a significant association between low birth weight (<2500 g) and delayed eruption of primary teeth. A more recent cross-sectional study, of 92 6-36-month children in the province of Cajamarca, Ludeña (2017), also found a positive association between infant malnutrition and delayed emergence of primary teeth.

Permanent dentition: To the best of our knowledge, the largest cross-sectional Peruvian study on the timing of emergence of the permanent dentition was done by Valenzuela et al. (2015) in Ucayali, the Amazon region, and involved 1,644 indigenous children aged 5 to 16 years. The findings showed no significant variations in the tooth emergence sequence when compared with other populations. However, there was a positive association between low weight and the delayed emergence of the permanent upper incisors. The emergence of the first permanent molars preceded the emergence of the incisors, and the upper second permanent molars were the last teeth to emerge. Teeth emerged earlier in females, the lower teeth emerged earlier than the upper teeth, and teeth on the right and left sides of the face emerged simultaneously.

Argote, Padilla and Begazo (2014), studied 178 children aged 6 to 13 years in Taquile Island, in the province of Puno (the Andes). The authors concluded there was no significant association between nutritional state (body mass index) and the timing of eruption of permanent teeth though they observed that one child with a very small body mass index had fewer emerged permanent teeth. Chalco (2015) studied 80 malnourished children aged 6 to 9 years and registered the dental development stage according to Moyers' classification; no statistically significant relationship between the timing of permanent tooth emergence and child malnutrition was found. In a recent cross-sectional study of 180 children in the city of Cusco, Farfán (2017) found that children with malnutrition or at risk of malnutrition had a higher percentage of non-erupted permanent teeth than those with normal nutritional status. Urcia (2010) also found a positive relationship between the delayed emergence of permanent teeth and poor nutritional status. Díaz-Orahulio and León-Manco (2014), in a study of 37 children younger than 12 years in Pachacámac, Lima, found no difference in the sequence of emergence of the permanent teeth in children who were malnourished and those not malnourished.

Developmental Dental Hard-tissue Anomalies

Anomalies of Tooth Number: Information about the prevalence of anomalies in the number of teeth in Peruvian children is limited. Most of the information comes from undergraduate theses.

Porras (1984) analyzed 1,320 panoramic radiographs of patients aged 5 to 18 years. He found that the prevalence of missing teeth was less than 1% in the primary dentition and 7.4% in the permanent dentition. In the permanent dentition, the most frequently missing teeth were the second lower premolars (3.7%), the second upper premolars (2.6%) and the upper lateral incisors (1.2%).

Cárdenas (1987) examined 1,644 3-6-year-old Peruvian children from Lima and found that the prevalence of missing primary teeth was 1.09%; the most affected teeth were the lower primary incisors. In the same year (1987), Cogan examined 1,200 14-17-year-old adolescent residents in Lima and found a prevalence of missing permanent teeth of 1.82%. Tarazona (1988) evaluated 1,800 radiographs of 14-17-year-old adolescents from Huanuco and found that 2.11% of the children had missing permanent teeth.

Pérez (1999) studied the prevalence of dental anomalies by analyzing 717 panoramic radiographs of 3-13-year-old children treated at the central clinic of a private university in Lima. The prevalence of missing teeth was 3.62%. The most common missing tooth was the lower second premolar

(37.5%), followed by the upper lateral incisor (16.07%). Ugarte (2011) also found that the lower second premolar (35.7%) and the upper lateral incisor (19%) were the first and second most prevalent missing teeth in a review of 1,083 panoramic radiographs in an 8-18-year-old population from Lima Children´s Hospital; the prevalence of missing teeth was 5.6%, with more missing teeth found in girls than in boys (60 vs. 40%). In 2018, Serrano (2018) reviewed the panoramic radiographs of 797 8-12-year-old children taken in a radiology center in Chiclayo and reported a prevalence of 6.1% of missing teeth: missing teeth were more frequent in girls than in boys (7.5% vs. 5.1%).

In 2014, Trevejo (2014) reviewed 1,710 panoramic radiographs of children and adults treated over a six-month period in 2011 at the radiology clinic of a private university in Lima (Universidad Peruana Cayetano Heredia). He found that the most prevalent dental anomaly was supernumerary teeth. There were no congenitally missing teeth.

There is also a high prevalence of missing teeth in children with cleft lip and palate. A study of 129 panoramic radiographs of patients with cleft lip and palate attending the Children´s Hospital in Lima by Mogollón and Huapaya (2008) showed the prevalence of hypodontia was 86.8%, with greater prevalence in boys than in girls (60.7% vs. 39.3%) and in children with bilateral rather than unilateral cleft and palate. Also, 36.3% of children had hypodontia of one tooth, and 30.4% had hypodontia of two teeth. The most commonly affected tooth was the maxillary lateral incisor (92.2%), followed by the maxillary second premolar (38.4%).

Anomalies of Shape and Size

Primary teeth: Masias Percca (2015) reviewed 494 panoramic and periapical radiographs of children 3-6 years of age attending a private university dental clinic in Lima, and reported a prevalence of 1% of size anomalies. Most of the anomalies were microdontia affecting the upper primary canines. Gemination and macrodontia were the least prevalent anomalies (0.2% of the total sample). The prevalence of anomalies affecting tooth shape was 11%, with the most prevalent shape being the peg-shaped lateral incisor.

Table 1. Summary of studies on missing teeth in the Peruvian population

Author CITY (year)	Age of Population	Sample size	Overall Prevalence	Most frequent missing teeth
Porras **LIMA** (1984)	5-18 years old	1,320	-	Second Lower premolars (3.7%) Second upper premolars (2.6%) Upper lateral incisor (1.2%)
Cárdenas **LIMA** (1987)	3-6 years old	1,644	1.09%	Lower primary incisors
Cogan **LIMA** (1987)	14-17 years old	1,200	1.82%	-
Tarazona **HUANUCO** (1988)	14-17 years old	1,800	2.11%	-
Pérez **LIMA** (1999)	3-13 years old	717	3.62%	Lower second premolars (37.5%) Upper lateral incisors (16.07%) Percentage of the missing teeth
Ugarte **LIMA** (2011)	8-18 years old	1,083	5.6%	Lower second premolars (35.7%) Upper lateral incisors (19%) Percentage of the missing teeth
Trevejo **LIMA** (2014)	Children and adults from a university clinic	1,710	None	-
Serrano **CHICLAYO** (2018)	8-12-year-old children	797	6.1 %	-

Permanent teeth: Casimiro (2016) reviewed 564 panoramic and periapical radiographs of children aged 7 to 14 years who attended a private university dental clinic in Lima. She found that 78% of her sample had shovel-shaped teeth, 19% had dens invaginatus, mainly affecting the lateral incisors, and 7% had peg-shaped lateral incisors. Alvarez Carpio (2016) analyzed 150 panoramic radiographs of children aged 6-12 years who attended the orthodontic department of a dental school in Cusco and found that 23% of patients had one form of dental anomaly. There was a 5% prevalence of anomalies of size and shape: the prevalence of macrodontia, and microdontia was less than 2%; and that of taurodontism and dens evaginatus was 1%.

Meneses (2017) conducted a clinical evaluation of 189 children aged 12 to 17 years old who attended a school in Puno, in the Andes region, and found a prevalence of 26% and 41% of size and shape anomalies respectively. The most common anomaly of size was microdontia (72%), while the most common anomalies of shape were dens evaginatus in 27% and peg-shaped laterals in 16% of the sample.

Anomalies of Structure

Publications on dental hard-tissue anomalies in the Peruvian population are limited. To the best of our knowledge, all published studies were limited to the developmental defects of enamel, molar incisor hypomineralization and fluorosis. We found no studies on inherited anomalies such as amelogenesis imperfecta and dentinogenesis imperfecta.

Developmental Defects of Enamel: Although all three geographical regions (the coast, highlands and jungle) have at least one city, three of the seven published studies were conducted in Lima (Taddei and Anduaga, 2012; Zapatel and Carrillo, 2015; Serrano and Callejas, 2017). Table 2 highlights the findings of studies on the developmental defects of enamel. Only two of the studies included children with primary dentition (Gonzalez and Valenzuela, 2017; Serrano and Callejas, 2017), while the other five enrolled children with mixed dentition, aged 6-13 years (Taddei and Anduaga, 2012; Ynga, 2013; Zapatel and Carrillo, 2015, 2014; Monzón, 2015; Pinheiro, Tapia and Perez, 2015). Three of the studies did not report the criteria used to assess the developmental defects of enamel, while the other four used the modified developmental defects of the enamel index (FDI, 1992). Only one study reported a process of calibration of the examiners (Zapatel and Carrillo, 2015).

The highest prevalence of defects was found in malnourished children and in pre-term children. Also, 70.1% of permanent teeth (Ynga, 2013) and 53.1% of primary teeth (Serrano and Callejas, 2017) had defects. The prevalence of developmental defects of enamel in children with no known risk factors ranged from 21.3% to 48.3%. The most frequent type of defect was demarcated opacities. There was no specific risk factor associated with the developmental defects of enamel as none of the studies were powered to identify risk factors.

Molar Incisor Hypomineralization and Hypomineralized Second Primary Molar: Table 3 is a list of 10 studies on molar incisor hypomineralization. Seven of the studies were performed in Lima and one (Aivar, De la Cruz and Aivar, 2016) was conducted in a city in the highlands. Three of the studies had clear criteria for assessing the presence and severity of molar incisor hypomineralization (Diaz, 2014; Dávila and Geller, 2016; Contreras and Ortíz, 2018); three studies reported criteria only for severity (Macagno, 2013; Cataciora, 2016; Jara and Barcena, 2016); and four studies did not report any criteria for their evaluation (Coylla, 2014; Aivar, De la Cruz and Aivar, 2016; Marcelo and Mayta, 2016; Quispe and Caballero, 2017). Only three investigations reported having calibrated examiners (Contreras and Ortíz, 2018; Dávila and Geller, 2016; Macagno, 2013).

The highest prevalence of molar incisor hypomineralization (70.2%) was reported in children living in an orphanage (Aivar, De la Cruz and Aivar, 2016), and in a group of children attending a hospital - 59% (Quispe and Caballero, 2017). In the general population, the prevalence of the lesion ranged from 6% to 43%. Macagno (2013) reported an atypically high prevalence of 63%; in that study, the criterion for molar incisor hypomineralization was not reported. The prevalence of the lesion in the two studies that reported their assessment criteria was 6% and 18.8% (Contreras and Ortíz, 2018; Dávila and Geller, 2016). The mild form was the most frequent form observed.

Table 2. Summary of studies on dental defects of enamel in Peruvian children

Author CITY (year)	Type of Population Type of Dentition (age)	Sample size	DDE evaluation criteria	Calibration	DDE General Prevalence	Most frequent DDE type
Gonzalez and Valenzuela **TUMBES** (2017)	School children in an urban community Primary dentition (3-5 y)	78	FDI Modified DDE index	No	29.5%	Demarcated opacities
Serrano and Callejas **LIMA** (2017)	Children in a major Hospital Primary dentition (6 m-5 y)	34 full-term 34 pre-term	FDI Modified DDE index	Unclear	34.4% 53.1%	Not reported
Monzón **AREQUIPA** (2015)	Female school children in an urban community Mixed dentition (8-12 y)	140	Not reported	No	44.0%	Demarcated opacities
Pinheiro, Tapia and Perez **IQUITOS** (2015)	Children in a public health facility Mixed dentition (7-12 y)	173	Not reported	No	Only hypoplasia: 5.2 %	_

Author **CITY** **(year)**	**Type of Population** **Type of Dentition** **(age)**	**Sample size**	**DDE evaluation criteria**	**Calibration**	**DDE General Prevalence**	**Most frequent DDE type**
Zapatel, Carrillo **LIMA** (2015)	School children in an urban community Mixed dentition (6-13 y)	323	FDI Modified DDE index	Yes, with pictures Kappa = 0.93	48.3%	Demarcated opacities
Ynga **CUSCO** (2013)	Malnourished children Mixed dentition (12 y)	64	FDI Modified DDE index	No	70.1%	Opacities
Taddei and Anduaga **LIMA** (2012)	Underserved community Mixed dentition (5-8 y)	286	Not reported	No	21.3%	Hypoplasia

One study of children under 6 years old, assessed the hypomineralized second primary molar (Quispe and Caballero, 2017). The prevalence by age and type of dentition was not defined, so the specific prevalence of this defect could not be ascertained.

Fluorosis: The prevalence of fluorosis was evaluated in two national epidemiological studies on the oral health profile of Peruvian children, which were designed and implemented by the General Office of Epidemiology of the Ministry of Health. School children aged 6 to 15 years were included, and the Dean index was used to assess the prevalence of fluorosis. The first study was carried out in 2001-2002 (published in 2005), and the second between 2012 and 2014 (unpublished). The first study reported a prevalence of 10.1% in permanent dentition: 7.5% of the lesions were very mild, 1.6% mild, 0.18% moderate, and 0.2% severe.

The second study reported a prevalence of 30.6% in permanent dentition, with no significant difference in prevalence between urban and rural dwellers. Some cities in the highlands had a higher prevalence than in cities on the coast or in the jungle. Also, in the total population 15.5% had very mild fluorosis, 9.4% mild, 7.1% moderate and 0.3% had severe fluorosis.

Table 3. Summary of studies on molar incisor hypomineralization in Peruvian children

Author CITY (year)	Type of Population (age)	Sample size	MIH evaluation criteria	Calibration	MIH Prevalence	Most frequent severity type
Contreras and Ortíz **LIMA** (2018)	School children in an urban community (6-12 y)	150	EAPD 2015 Severity: Mathu-Muju and Wright 2006	Yes Kappa = 0.77	6.0%	Mild mainly
Quispe and Caballero **LIMA** (2017)	Children attending a major Hospital (3-13 y)	100	Not reported	No	MIH and HSPM: 59.0. %	Not reported
Aivar, De la Cruz and Aivar **AYACUCHO** (2016)	Children in an orphanage (6-12 y)	60	Not reported	No	70.2%	Not reported
Catacora **AREQUIPA** (2016)	School children in an urban community (7-12 y)	150	Not reported Severity: Mathu-Muju and Wright 2006	No	43.3 %	Moderate
Dávila and Geller **LIMA** (2016)	School children in an urban community (8-11 y)	229	Weerheijm 2003 Severity: Mathu-Muju and Wright 2006	Yes	18.8%	Mild mainly

Author CITY (year)	Type of Population (age)	Sample size	MIH evaluation criteria	Calibration	MIH Prevalence	Most frequent severity type
Jara and Barcena **TACNA** (2016)	School children in an urban community (5-6 y)	53	Not reported Severity: Mathu-Muju and Wright 2006	No	30.2%	Mild mainly
Marcelo and Mayta **LIMA** (2016)	School children in an urban community (5-13 y)	142	Not reported	Unclear	30.2%	Mild mainly
Coyla **LIMA** (2014)	Children attending a dental clinic (8-10 y)	150	Not reported	Unclear	40.0%	Mild mainly
Diaz **LIMA** (2014)	Children attending a dental clinic (7-12 y)	150	Weerheijm 2003 Severity: Mathu-Muju and Wright 2006 (severity)	Unclear	30.0%	Mild mainly
Maccagno and Flores **LIMA** (2013)	School children in an urban community (6-12 y)	197	No reported Severity: Mathu-Muju and Wright 2006	Yes Kappa = 0.69	63.4%	Mild mainly

Gaps and Recommendations

In general, data on dental anomalies in Peruvian children are scarce. We have tried to present and summarize most of the studies that have been carried out throughout the country. Most sources of information were undergraduate theses, and the limited number of studies published as original articles were published in non-indexed local journals, which likely did not go through the proper peer review. Also, in most cases, sample sizes are small, probably due to Peru's limited resources for conducting research. A considerable proportion of studies does not have clear evaluation criteria, including the national surveys conducted. Examiners in most of the studies were not calibrated, and statistical methods used were not adequately described, a problem especially unfavorable for studies on structural anomalies.

In light of this situation, we recommend that scientific societies and other academic institutions provide user-friendly guidelines on how to improve the design and methods of studies on tooth eruption and developmental dental anomalies. The great variability in study methodology makes it difficult to compare findings among studies in Peru and other global studies. The current studies have also not assessed the risk factors for many developmental dental anomalies, and the dental anomalies identified have been limited. Our country needs well-designed, cross-sectional descriptive studies that will generate information to help with the planning of analytical studies.

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Russia

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Background Information on Russia

The Russian Federation, also known as Russia, is the largest country in the world. Its vast territory lies in the eastern part of Europe and the northern part of Asia. The country is washed by three oceans (the Arctic, Atlantic, and Pacific Oceans) and twelve seas (the White Sea, Barents Sea, Okhotsk Sea, Baltic Sea, Black Sea, Caspian Sea, Azov Sea, and others). Russia borders many countries: Norway, Finland, Estonia, Latvia, and Lithuania in the north; China, Mongolia, North Korea, and others in the southeast; Poland, Belarus, and Ukraine in the west; and others, as shown in Figure 1.

Russia's terrain varies from forests to deserts and from high mountains to deep valleys. The Caucasus and Altai mountain ranges are along its southern borders, and the Verkhoyansk Range is in the eastern region. Mount Elbrus, in the western part of the Caucasus, is the highest point in Russia and Europe, at 5,633 meters. The more central, north-south Ural Mountain Range forms the primary divide between Europe and Asia. The country has many large rivers and deep lakes. Notable rivers are the Volga, Don, Kama, Oka, and the Northern Dvina. Other rivers, such as the Dnieper and the Western Dvina, originate in Russia, but flow into other countries.

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Figure 1. Map of Russia

Russia's climate ranges from arctic and subarctic in the north to continental in the center to subtropical in the south. The country's geographic position and climate influence its economy, lifestyle, population, health, and national character. Russia is extremely rich in natural and mineral resources: deposits of oil, gas, iron, gold, non-ferrous metals, and many other minerals.

The population of Russia is about 147 million. The capital of the Russian Federation, Moscow, has a population of about 17 million. The country is a Republic headed by a president. Russia is multi-national and multi-religious, though most of its citizens are Russian Orthodox.

In Russia, dental care is free for all children under 18 years old; the care is covered by the Federal Compulsory Medical Insurance Fund, also known as National Healthcare Insurance. Numerous regulations guide the protocols under which pediatric dental-care providers work. The Russian Federation Pediatric Dental Care Guidelines include provisions for the treatment of maxillofacial pathologies in children (Leontjev and Kiselnikova, 2010; 2017). Pediatric Dentistry is a distinct specialty, but both specialized pediatric dentists and general dental practitioners can provide pediatric dental care. There are separate pediatric dental clinics and departments in Russia. Within public institutions for children, pediatric dental care, including regular check-ups and preventive measures, is given in dental offices based in schools and kindergartens. Private and public pediatric dental clinics provide oral health care services for children.

Timing and Sequence of Emergence of Primary Teeth

The published studies on primary teeth emergence are single-center studies in various Russian regions. In Russia's central region, Elizarova and Zueva (2002) found the following sequence of emergence: lower central incisors, upper central incisors, lower lateral incisors, upper lateral incisors, lower canines, upper canines, first lower molars, first upper molars, second lower molars, and second upper molars. Galonskyet al. (2012) determined primary teeth emergence in children from Krasnoyarsk in the Siberian region. Their study was conducted ten years after Elizarova and Zueva's (2002) study, and they reported a slightly different emergence sequence: lower central incisors, upper central incisors, upper lateral incisors, lower lateral incisors, first upper molars, first lower molars, upper canines, lower canines, second upper molars, and second lower molars. The average emergence times from these two studies are summarized in Table 1.

Primary teeth emergence is influenced by many factors, such as genetics, breastfeeding duration, mother's health during pregnancy, and health of babies at birth. Factors that affect children during the antenatal period can influence the timing of eruption. One study found that premature children had delayed tooth eruption. In this study, the first primary teeth erupted at ≥8 months of age in 61% of premature children (Elizarova, Zueva, and Butova, 2002).

Table 1. Time of primary teeth emergence in Russian children

Tooth	Mean time of emergence	
	Elizarova and Zueva (2002)	Galonsky and Radkevich (2012)
Lower central incisors	5.3±0.22 months	5-9 months
Upper central incisors	6.6±0.26 months	6-11 months
Lower lateral incisors	7.6±0.34 months	8-13 months
Upper lateral incisors	8.4±0.22 months	7-13 months
Lower canines	15.8±0.3 months	15-22 months
Upper canines	16.3±0.32 months	14-22 months
First lower molars	12.8±0.26 months	12-17 months
First upper molars	13.3±0.32 months	11-17 months
Second lower molars	22.3±0.24 months	19-27 months
Second upper molars	23.0±0.33 months	

Timing and Sequence of Emergence of Permanent Teeth

Table 2 shows the time of permanent teeth emergence, as described in two studies conducted in different parts of Russia. In the Siberian region, Galonsky et al. (2012) found that all of the permanent teeth, except the premolars, erupted in the lower jaw before they erupted in the upper jaw. The sequence of eruption for each jaw is represented below.

$M^1 I^1 I^2 P^1 P^2 C \uparrow M^2$ for the maxilla
$M_1 I_1 I_2 P^1 C \downarrow P_2 M_2$ for the mandible

For children living in the Urals, the permanent teeth started emerging at the end of the fourth year. All permanent teeth, except the third molar, emerged by 14 years of age. The central and lateral incisors, canines, second premolars, and first molars started emerging at the same time in girls and boys. The first premolars and the second molars started emerging one year later in boys than in girls. Despite this, the average time of tooth emergence is the same for both genders. Teeth emerged 4-

7 months earlier in girls than in boys (Bimbas and Saipeeva, 2016).

For 95% of children who resided in the central part of Russia, tooth eruption was complete at four years for the central incisors; five years for the first molars; five to six years for the lateral incisors; and seven to nine years for the canines, premolars, and second molars. The number of emerged permanent teeth was significantly higher in girls than in boys in the early and middle phase of eruption, but not in the later phase (Alimsky, 2015).

Table 2. Time of permanent teeth emergence in Russian children

Tooth	Time of emergence	
	Galonsky et al. (2012)	Alimsky (2015)
Lower central incisors	4-7	6-7
Upper central incisors	5-8	6
Lower lateral incisors	5-8	6-9
Upper lateral incisors	6-9	6-7
First lower molars	4-7	5-6
First upper molars	4-7	5-6
Lower canines	8-12	8-12
Upper canines	9-13	8-11
Lower first premolar	8-11	8-11
Upper first premolar	7-11	7-11
Lower second premolar	8-12	8-12
Upper second premolar	8-12	8-13
Second lower molars	9-13	9-13
Second upper molars	10-13	9-12

Developmental Dental Hard-tissue Anomalies

The 2008 National Oral Health Survey in Russia found that the prevalence of enamel hypoplasia was27% in12-year-oldsand 28% in 15-year-olds(Kuzmina et al., 2009).Also, 34% of12-year-olds and 31% of 15-year-oldswho resided in regions with high fluoride concentrations in the drinking water had fluorosis. Most Russian regions had low fluoride concentrations in the water; however, some towns in the Moscow region had concentrations as high as 1.84mg/lto 3.45mg/l. The Nizhegorodsky region also had high fluoride concentrations, ranging from 1.04mg/l to 3.18mg/l. Other regions with high concentrations were the Penza region (1.99 mg/l), the Ryazan region(2.17mg/l to 3.57mg/l), the Tver region (1.04mg/lto 1.33mg/l),the Republic of Udmurtia (1.95mg/l to 4.00mg/l), and the Republic of Chuvashia (2.18 mg/l).

Other investigators reported the following fluorosis prevalence:19.3% in children in the Samara region(Nogina and Khamadeeva, 2009); 70% in Tver (Belyaev and Mitina, 2003) and 52.3% in 3-15-year-olds in Irkutsk(Savchenkov and Yankovsky, 2005).Dental fluorosis was reported in regions with increased water fluoride concentrations as well as those without increased concentrations.

One study found that the prevalence of chronologic permanent teeth enamel hypoplasia in children of Ekaterinburg was 39.2% (Ozhgikhona, 2011).The causes of chronologic enamel hypoplasia included hypoxia neonatorum and systemic diseases in the first year of life.

Kuznima et al. (2009) reported that the prevalence of non-carious lesions in various regions of Russia depended on the water fluoride concentration. In places where the concentration was lower than 0.7mg/l, the prevalence of spotty hypoplasia was 27% in 12-year-old children and28% in 15-year-olds. Also, the prevalence of fluorosis was 3% in12-year-old children and 2% in 15-year-olds. In regions where the water fluoride concentration was higher than 0.7mg/l, the prevalence of spotty hypoplasia was 12% in 12-year-olds and 15% in 15-year-olds. The fluorosis prevalence was 34% in12-year-old children and 31% in 15-year-olds.

Gaps and Recommendations

To reduce acquired diseases of teeth development in children in Russia, preventive measures should be optimized. Such measures included preventing toxicosis in pregnant women, and improving the health of children in the first years of life.

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The Kingdom of Saudi Arabia

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Background Information on the Kingdom of Saudi Arabia

The Kingdom of Saudi Arabia, in the southwestern part of Asia, is one of the largest countries in the Middle East, with a total area of 2.24 million km^2, covering nearly four-fifths of the Arab Peninsula (Al-Qatari and Haran, 1999; Aldossary,While, and Barriball, 2008; Walston, Al-Harbi, and Al-Omar, 2008; Almalki, Fitzgerald, and Clark, 2011). Saudi Arabia is bordered by Jordan and Iraq to the north, Kuwait to the northeast, Qatar, Bahrain and the United Arab Emirates to the east, Oman to the southeast, and Yemen to the south. It is separated from Israel and Egypt by the Gulf of Aqaba. It is the only nation with both a Red Sea coast and a Persian Gulf coast. Most of its terrain consists of arid desert and mountains, as illustrated in Figure 1 (Ministry of Health and Statistics, 2006).

Preventive, curative and rehabilitative health-care services are provided by the government (Alnaif, 2006; Walston, Al-Harbi, and Al-Omar, 2008; Alkhamis, 2012), mostly through the Ministry of Health (Ministry of Health and Statistics, 2006). Three categories of health services are provided: the first tier is primary health care, provided through primary

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health centers to all cities, towns, and villages; the focus is on preventing illnesses, enhancing and maintaining health, and educating people about their health issues. The second tier is provided through general hospitals, specialized clinics, and operating rooms for operations. These facilities provide medical care that is beyond the limits of primary health services. When patients need more advanced and complex treatments in multiphase, they are referred to the tertiary health care centers, which include specialized hospitals and oncology centers (Aldossary, While, and Barriball, 2008). The third category of care is that in which the Ministry of Health monitors, advises, and evaluates health-care-related activities carried out by the private sector (Ministry of Health and Statistics, 2006; Aldossary, While, and Barriball, 2008; Alkhamis, 2012).

Figure 1. Map of the Kingdom of Saudi Arabia

In Saudi Arabia, drinking water is obtained from several sources: groundwater from wells, desalinated seawater and, recently, bottled water, which has been gaining popularity (Alabdula'aly, 1997). A few studies have evaluated the fluoride levels in drinking water in various regions of the Kingdom. In Riyadh, the capital city, the fluoride level in tap water collected from schools was 0.00 to 6.20 parts per million. Seventy-five per cent of the population received between 0.00 and 0.30 parts per million of fluoride, which is very low. Only 28.63% received 0.81 parts per million (AlDosari, Akpata, and Khan, 2003), which is a higher fluoride content than that reported in some cities in the Makkah area (Al-Khateeb, Al-Marsafi, and O'Mullane, 1991) and the Hail region (Akpata, Fakiha and Khan, 1997). In the Mekkah area, the fluoride content in drinking water ranged from 0.30 parts per million in the city of Jeddah to 2.47 in Mekkah (Al-Khateeb, Al-Marsafi, and O'Mullane, 1991). Akpata ES, Fakiha Z, and Khan N (1997) reported that the content of fluoride in the Hail region, where most families depend on well groundwater as their main drinking water resource, ranged between 0.54 and 2.85 parts per million. The high level of fluoride has caused an endemic of dental fluorosis, but it has had little influence on the prevalence of dental decay among 12-15-year-old children.

Recently, bottled water gained popularity among the Saudi population. The fluoride content in most of the available brands in the Kingdom was below the recommended level (Alabdula'aly, 1997; Alabdula'aly and Khan, 1999; Zahid, 2002). In 2010, Aldrees and Al-Manea (2010) reported that the mean fluoride content in drinking bottled water was 0.79 mg/l, with a range of 0.5 to 0.83 mg/l. The manufacturers' labeling of fluoride content was inaccurate in some brands (Aldrees and Al-Manea, 2010).

Saudi Arabia is one of the fastest growing economies, and was the world's 19^{th} largest economy in 2013. In addition, 1.7 million jobs were created for Saudisand billions have been invested in health, education, and infrastructure, with the aim of improving living standards and quality of life. Due to the changing global energy market, the Kingdom cannot continue to grow based on oil; its economy should shift to one that is more sustainable and less oil-dependent (McKinsey Global Institute, 2015).

It has been estimated that up to 10.7% of male and 12.7% of female citizens in the Kingdom are overweight (El-Hazmi and Warsy, 2002). The sedentary lifestyle, the dramatically increased intake of fast food, and the unhealthy low consumption of fruit, vegetables and milk products (Alsubaie, 2018) have contributed to the increased number of overweight or obese children (Naeem, 2012; Hopping et al., 2010).

Timing and Sequence of Emergence of Primary and Permanent Dentitions

Standards on the timing and sequence of eruption of teeth are an important resource for general dental practitioners and specialists who manage dental problems in growing children (Ministry of Health and Statistics, 2006). Several studies have shown variations in the ages at which individual primary teeth emerge as well as variations of emergence patterns among ethnic and racial groups (Alkhamis, 2012; Almalki, Fitzgerald and Clark, 2011; Ministry of Health and Statistics, 2006). It is desirable to have reference standards that ensure international comparability to assist clinicians in diagnosing cases of delayed or advanced tooth eruption (Allazzam, Alaki and El Meligy, 2014; Alnaif, 2006). Three studies published in the last three decades have reported on the age and sequence of emergence of the primary and permanent teeth in Saudi Arabia (Table 1). These studies were carried out in Riyadh by Al-Jasser and Bello (2003) and Chohan et al. (2007), and in both Riyadh and Qassim by Alsaleh et al. (2017). The study by Al-Jasser and Bello (2003) was hospital-based; that by Chohan et al. (2007) was schools-based; and that by Alsaleh et al. (2017) was population-based, with subjects randomly recruited from malls.

Al-Jasser and Bello (2003) provided data on the age and sequence of emergence of the primary teeth. Tooth emergence was completed in 19.5 months in the mandible and in nearly 17 months in the maxilla. Four phases of tooth emergence were identified – incisors, first molars, canines, and second molars – with periods of rest between the phases.

Alsaleh et al. (2017) assessed the time of emergence of the primary central incisors in children resident in Riyadh and Buraidah. They reported a younger age of emergence for the primary central incisors than the emergence reported by Al-Jasser and Bello (2003). The difference in results may be due to differences in study methodology.

For the permanent dentition, Chohan et al. (2007) determined the emergence of the incisors and first permanent molars in primary school children. Like Al-Jasser and Bello (2003), they identified the phases and sequence of emergence of the first permanent molar and incisors. They found that the sequence of emergence was upper first molars, lower central incisors, lower first molars, upper central incisors, lower lateral incisors, and upper lateral incisors. Table 1 highlights this sequence of eruption.

Table 1. Cross-sectional studies assessing the sequence of emergence and emergence time in regions in the Kingdom of Saudi Arabia

Reference	Setting and method	Method and duration	Sample size	Age	Definition of eruption	Results		
						Sample size	Tooth	Mean age in months (SD)
Al-Jasser and Bello, 2003	Hospital-based King Khalid and King Abdulaziz University Hospitals, Riyadh, SA	Clinical examination June 1997 and May 1999	728	4-40 months	Tooth with any part of its crown penetratin g the gingiva and visible in the oral cavity		Primary upper right and left central incisors	11.2 (1.9)
							Primary upper right and left lateral incisors	13.2 (2.72)
							Primary upper right and left canines	21.09 (3.66)
							Primary upper right and left first molars	16.89 (3.36)
							Primary upper right and left second molars	28.21 (4.18)
							Primary lower right and left central incisors	8.47 (2.81)
							Primary lower right and left lateral incisors	14.5 (3.6)
							Primary lower right and left canines	21.07 (3.73)
							Primary lower right and left first molars	17.15 (2.73)

Reference	Setting and method	Method and duration	Sample size	Age	Definition of eruption	Results		
						Sample size	Tooth	Mean age in months (SD)
							Primary lower right and left second molars	27.95 (4.06)
Chohan et al., 2007	Multi-school based, three governmental and one private, Riyadh	Clinical examination 2004	612	School grades I to III	Tooth considered emerged when any part was visible	14	Upper right permanent first molar	77.4 (3.9)
						103	Upper right permanent lateral incisor	98.4 (6.5)
						98	Upper right permanent central incisor	89.0 (7.4)
						100	Upper left permanent central incisor	88.2 (7.1)
						81	Upper left permanent lateral incisor	96.0 (5.7)
						21	Upper left permanent first molar	78.7 (5.3)
						75	Lower left permanent first molar	83.4 (6.9)
						150	Lower left permanent lateral incisor	92.1 (8 3)
						97	Lower left permanent central incisor	82.6 (7.7)
						84	Lower right permanent central incisor	82.6 (8.2)

Reference	Setting and method	Method and duration	Sample size	Age	Definition of eruption	Results		
						Sample size	Tooth	Mean age in months (SD)
						162	Lower right permanent lateral incisor	92.7 (8.8)
						83	Lower right permanent first molar	84.0 (7.6)
Alsaleh et al., 2017	Community based Zulfi city mall, Zulfi, Alnakheel mall, Riyadh and Al Othaim Mall, Buraidah, Qassim	Questionnaire October and November 2016	75 M: 42 F: 33	6-36 months		75	Upper primary central incisors	9.227
						75	Lower primary central incisors	7.25

Relation between Dental Age and Chronological Age

Children's age can be estimated by evaluating the pattern of dental development and the sequence of eruption. However, the accuracy and reliability of dental age vary among populations (Nystrom et al., 1986; Mornstad, Reventlid, and Teivens, 1995; Nykanen et al., 1998). In Saudi Arabia, five studies evaluated the relationship between the estimated dental age and chronological age (Al-Emran, 2008; Alshihri, Kruger and Tennant, 2015; Nour et al., 2016; Al-Dharrab et al., 2017; Alsudairi and AlQahtani, 2019).The studies were carried out in Riyadh, Jeddah and Qassim cities. Three of the studies (Al-Emran, 2008; Al-Dharrab et al., 2017; Nour et al., 2016) used the Demirjian method (Demirjian, Goldstein and Tanner, 1973). Significant differences were found between children's chronological age and estimated dental development for both boys and girls. Whereas Al-Emran (2008) and Al-Dharrab et al. (2017) reported that dental age was overestimated compared to chronological age when using the Demirjian method, and Nour et al. (2016) felt that dental age was slightly underestimated when compared to chronological age, using the same method. Table 2 highlights the results of the studies.

Another method for estimating dental age is the London Atlas of Human Tooth Development and Eruption. It was recently reviewed and covers dental development and eruption sequences from the age of 1 to 23 years. It is considered a well-developed, comprehensive and evidence-based method of age estimation (AlQahtani, Hector and Liversidge, 2010). Alshihri, Kruger and Tennant (2015) and Alsudairi and AlQahtani (2019) evaluated the relationship between chronological age and estimated dental age, using the London Atlas of Human Tooth Development. Both studies found no significant differences between the real chronological age and the estimated dental age, indicating that the Atlas is a more reliable method for age estimation in Saudi Arabia. In addition, Alsudairi and AlQahtani (2019) evaluated the use of Cameriere's formula, which measures projections of open apices of developing teeth, and compared it to the London Atlas of Human Tooth Development. They reported no significant difference between the accuracy of the two references.

Table 2. Cross-sectional studies comparing chronological age with dental age in various regions in the Kingdom of Saudi Arabia

Reference	Setting	Dental age method	Age group in years	Number	Chronological age mean in years (SD)	Dental age mean in years (SD)	Differences mean in years (SD)	Significance
Al-Emran S, 2008	Multi-hospital based Three large dental centers in Riyadh city	Demirjian	9-16	940 M: 225 F: 265	12.39 (2.31) 12.38 (2.39) 12.39 (2.39)	12.75 (1.69) 12.7 (1.71) 12.81 (1.79)	-0.37 (0.82) -0.31 (0.83) -0.42 (0.85)	<0.001* <0.001* <0.001*
Alshihri, Kruger and Tennant, 2015	Pedodontics Orthodontic and Dental Centre, King Fahd Hospital, Jeddah	London Atlas of Human Tooth Development and Eruption	4-20	252 M: 110 (44%) F: 142 (56%)	11.01 (5.9)	10.91 (4.87)	0.1 (0.4)	0.595
Nour et al., 2016	Faculty of Dentistry, Qassim University	Demirjian and Goldstein	4-14	400 M: 222 F: 189	a	a	0.36 (0.11) 0.3 (0.09) 0.41 (0.11)	P <0.001*

Reference	Setting	Dental age method	Age group in years	Number	Chronological age mean in years (SD)	Dental age mean in years (SD)	Differences mean in years (SD)	Significance
Al-Dharrab et al., 2017	Hospital-based Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia	Demirjian	3-17	1,902 M: 955 F: 9,647	9.94 (4.33) 9.94 (4.42) 9.94 (4.41)	10.04 (4.29) 10.44 (4.68) 9.64 (4.29)	-0.098 (0.85) -0.497 (0.95) 0.3 (0.51)	<0.001* <0.001* <0.001*
Alsudairi and AlQahtani, 2019	Pediatric Dental clinics of King Saud University, College of Dentistry, Riyadh	London Atlas of Human Tooth Development and Eruption	6-16	M: 200 F: 200	a	a	-0.59 (1.45)	P >0.05
		Cameriere's formula			a	a	-0.89 (1.14)	P >0.05

*: significant level <0.05; a: numbers not mentioned in the study

Factors Affecting the Timing and Sequence of Tooth Emergence

Age and weight have independent effects on the timing of eruption of primary teeth in Saudi Arabia (Alnemer and Pani, 2017). Before teeth could emerge, a threshold weight had to be achieved: heavier children were likely to have more erupted teeth in the first year of life. Also, exclusively breastfed children were significantly more likely to have an erupted primary tooth. Teeth in females emerged at lower weights than in males of the same age. Even though age was highly correlated with the number of teeth erupted, the wide range of normal age-for-tooth emergence makes it challenging to use delay in tooth emergence as a reliable index for determining growth inadequacy in Saudi Arabia (Alnaif, 2006).

Developmental Hard Dental-tissue Anomalies

Table 3 highlights publications in the last three decades on developmental hard dental-tissue anomalies in Saudi Arabia. Several studies to determine the prevalence of these lesions had been conducted in Riyadh, Makkah, Eastern Province, Qassim and Asir regions.

Riyadh Region

The earliest study conducted in Riyadh was by Al-Emran (1990) of 500 male children. The prevalence of hypodontia in the permanent teeth was 4%. Tooth malformations – mainly peg-shaped upper lateral incisors – also were observed in about 4% of the sample. The prevalence of molar-incisor hypomineralization in females was 40.6% (Al-Hammad, 2017).

Western Region

In Jeddah, the prevalence of 10 selected dental anomalies was assessed among 1,010 dental patients. Results showed that 9.41% of the study population had hypodontia, the most prevalent lesion. The prevalence of taurodontism and microdontia was 8.61% and 5.35%, respectively. Anomalies with lower prevalence were dilacerations and transposition – 1.19% and 0.20%, respectively (Ghaznawi, Daas and Salako, 1999). Afify and Zawawi (2012) have reported a prevalence of 25.7% for congenitally missing teeth in the western region of Saudi Arabia; almost 20% of affected patients had at least 3-4 missing teeth.

Qassim Region

Rugg-Gunn, Al-Mohammadi and Butler (1997) studied the effects of fluoride levels in drinking water, nutritional status, and socioeconomic status on the prevalence of developmental defects of dental enamel in permanent teeth. A total of 1,539 children who had resided continuously in that community were examined. Overall, 83% of study participants had one or more enamel defects. The mean number of teeth affected per person was 9.6. Diffuse defects were the most common lesion.

Asir Region

Yassin (2016) investigated the prevalence and factors associated with dental anomalies among children in Abha, an urban city and the capital of the Asir region. The study concluded that 23.08% of study participants had at least one dental anomaly. Congenital missing teeth (9.7%) was the most common anomaly followed by the presence of supernumerary teeth (3.5%). Structural anomalies were the least common anomaly, with dentinogenesis imperfecta (0.1%) being the rarest anomaly, followed by amelogenesis imperfecta (0.3%).

Other Regions

In Gizan, the capital of the Jizan Region, 2,393 children, 4 to 12 years old, were screened for dental anomalies. The most common dental anomaly was hypodontia, with a prevalence of 2.2%. Other anomalies were supernumerary teeth (0.50%), peg-shaped lateral incisors (0.37%), and gemination (0.08%) (Salem, 1989).

In Tabuk, the capital city of the Tabuk Region, 1,878 children attending the North-West Armed Forces Hospital were screened for missing teeth, fused teeth, talon cusps, and supernumerary teeth, including mesiodens. The most frequently missing tooth was the mandibular second premolar. Forty-eight per cent of patients had missing teeth (Osuji and Hardie, 2002).

Al-Jouf Province is a growing rural province, with a population of 440,009 people. Sajjad et al. (2016) determined that the prevalence of hypodontia in a sample of 1,267 patients who presented to the outpatient clinics of the Orthodontic and Prosthodontic Departments of a hospital in the province was 6.1%.

Table 3. Overview of studies describing the prevalence of hard dental-tissue anomalies in the Kingdom of Saudi Arabia

S.no	Study	Authors	Year	Location	Prevalence
1	Prevalence of selected dental anomalies in Saudi children from the Gizan region	Salem, G	1989	Gizan	Congenitally missing teeth: 2.2% Supernumerary teeth: 0.50% Gemination: 0.08% Peg-shaped lateral incisors: 0.37%
2	Prevalence of hypodontia and developmental malformation of permanent teeth in Saudi Arabian school children	Al-Emran, S	1990	Riyadh	Hypodontia: 4% Tooth malformations: 4%
3	Prevalence of shovel-shaped incisors in Saudi Arabian dental patients	Saini et al.	1990	Riyadh	Central shovel-shaped incisors: 4% Lateral shovel-shaped incisors: 11%
4	Impacted cuspids in a Saudi population: prevalence, etiology and complications	Zahrani	1993	Riyadh	Cuspid impaction: 3.6%
5	Hypodontia of primary and permanent teeth in a sample of Saudi children	Salama and Abdel-Megid	1994	Riyadh	Hypodontia: 2.6%
6	Effects of fluoride levels in drinking water, nutritional status, and socioeconomic status on the prevalence of developmental defects of dental enamel in permanent teeth in Saudi 14-year-old boys	Rugg-Gunn, et al.	1997	Jeddah Riyadh Qassim	Enamel defects: 83%

S.no	Study	Authors	Year	Location	Prevalence
7	Malnutrition and developmental defects of enamel in 2-6-year-old Saudi boys	Rugg-Gunn et al.	1998	Riyadh	Enamel defects: 39%
8	Prevalence of the Carabelli trait in Saudi Arabian children	Salako and Bello	1998	Jeddah	Carabelli trait: 58.7%
9	A clinical and radiographic survey of selected dental anomalies and conditions in a Saudi Arabian population	Ghaznawi et al.	1999	Jeddah	Hypodontia: 9.41% Taurodontism: 8.61% Microdontia: 5.35% Diastema: 4.46%
10	Dental anomalies in a population of Saudi Arabian children in Tabuk	Osuji and Hardie	2002	Tabouk	Missing teeth: 59% Supernumerary teeth: 20.8% Fused teeth: 6%
11	Developmental enamel defects and their association with dental caries in preschoolers in Jeddah, Saudi Arabia	Farsi	2010	Jeddah	Enamel defects: 45.4%
12	The prevalence of dental anomalies in the Western region of Saudi Arabia	Afify and Zawawi	2012	Jeddah	Congenitally missing teeth: 25.7% Impacted teeth: 21.1% Dilacerated teeth: 1.1% Supernumerary teeth: 0.3% Odontoma: 0.1% Taurodontism: 0.1%
13	Consanguinity-related hyperdontia: An orthopantomographic study	Shokry and Alenazy	2013	Riyadh	Non-syndromal supernumerary teeth: 1.2%

S.no	Study	Authors	Year	Location	Prevalence
14	Prevalence of dental anomalies in Saudi orthodontic patients	AlJabaa and Aldrees	2013	Riyadh	Impaction: 51.4% Hypodontia: 20% Microdontia: 12.5% Macrodontia: 8.4% Ectopic eruption: 4.7% Supernumerary: 3.5%
15	The prevalence of some dental anomalies on panoramic radiographs in the Saudi population in Al-kharj city	Diab	2013	Al-kharj	Dilacerated roots: 20% Hypodontia: 15.4% Taurodontism: 5.7% Supernumerary teeth: 5.4% Hypoplastic teeth: 3.4% Short roots: 1.7% Transposition: 1.4%
16	Molar incisor hypomineralization, prevalence, and etiology	Allazzam et al.	2014	Jeddah	Molar incisor hypomineralization: 8.6%
17	Radiographic assessment of impacted teeth and associated pathosis prevalence. Pattern of occurrence at different ages in Saudi male in Western Saudi Arabia	El-Khateeb et al.	2015	Al-Madinah	Impacted teeth: 34.5% Associated pathosis among impacted mandibular third molars: 31.5% Associated pathosis among impacted maxillary third molars: 18.2%
18	Prevalence and distribution of selected dental anomalies among Saudi children in Abha, Saudi Arabia	Yassin	2016	Abha	Hypodontia: 9.7% Hyperdontia: 3.5% Microdontia: 2.6% Macrodontia: 1.8% Talon cusp: 1.4%

S.no	Study	Authors	Year	Location	Prevalence
					Taurodontism: 1.4% Fusion: 0.8% Ectopic eruption: 2.3% Rotation: 0.4% Amelogenesis imperfecta: 0.3% Dentinogenesis imperfecta: 0.1%
19	Prevalence of maxillary lateral incisor agenesis and associated skeletal characteristics in an orthodontic patient population	Bassiouny et al.	2016	Jeddah	Maxillary lateral incisor agenesis: 4.9%
20	A retrospective cross-sectional study on the prevalence of hypodontia in a target population of Al-Jouf Province, Saudi Arabia	Sajjad et al.	2016	Al-Jouf	Hypodontia: 6.1%
21	Molar-incisor hypomineralization in a group of female children in Riyadh: prevalence and clinical characteristics	Al-Hammad	2017	Riyadh	Molar incisor hypomineralization: 40.6%
22	Incidental dental anomalies in pediatric dental patients detected by panoramic radiographs - a retrospective study	Bawazir et al.	2019	Jeddah	Hypodontia: 9.7% Canine impaction: 9% Dilaceration: 7.1% Other teeth impaction excluding third molar: 3.2% Fusion: 0.1% Short root: 0.1% Odontoma: 0.1%

Gaps and Recommendations

Need for More Studies on Eruption Time

Research on the sequencing and time of tooth emergence still is at a preliminary stage in Saudi Arabia. Systemic, genetic and local factors that influence tooth development and calcification need to be investigated. In addition, stages and time of hard-tissue formation, the amount of enamel formed at birth, and enamel and root completion are areas of research that need to be elaborated. Finally, a national cohort study is recommended to confirm eruption time.

Need for More Data on Hard Dental-tissue Anomalies

Several studies have investigated the prevalence of dental anomalies in Saudi Arabia; showing that dental anomalies are a prevalent problem. However, findings are not representative of the entire Saudi community. To better understand the conditions in the country, a national oral-health survey needs to be conducted. The observed prevalence of hard dental-tissue anomalies in Saudi Arabian children is high; there is a need for increasing awareness of dentists and public health authorities about this alarming dental problem and for carefully planned short- and long-term preventive and therapeutic programs and nationwide larger-scale epidemiological studies.

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SERBIA

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Background information on Serbia

The Republic of Serbia is located in the Balkans, covering 88,509 km^2. Serbia is divided into 29 districts, with the capital city of Belgrade. According to the 2011 Census, the population of the country is 7,186,862. Most of the people are Serbs, Hungarians, Albanians, Roma and Bosnians. The population is constantly decreasing, with lots of elderly. It is one of the oldest populations in Europe – 17.5% of people are more than 65 years of age. One of the possible reasons might be the high emigration of younger people for economic reasons. The increase in mortality rate has been constant since 2005. In addition, there is negative population growth due to the reduction in the birth rate (Bogdanovic et al., 2016).

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Figure 1: The map of Serbia

The main event in recent history that had influenced the lives and health of Serbian citizens was the Kosovo crisis in 1999. The civil war in neighbouring Bosnia and Herzegovina (1992-95), and most recently, the civil war in Kosovo and the NATO attack in 1999 resulted in extensive environmental damage including huge economic, humanitarian, and ecological consequences (Clarke, 2002). Although a major environmental catastrophe was avoided, serious threats to the ecosystem and human health are still present. Bombing led to the release of metallic mercury, dichloroethane, vinyl chloride monomer, liquid ammonia, and oil products. These toxins have caused significant chronic pollution and deleterious effects on ecosystems of the rivers Danube and Sava. In addition, the use of depleted uranium ammunition produced secondary toxins (Balkans Task Force Biodiversity Mission, 1999; Balkans Task Force Desk Assessment Group, 1999).

Hon and his colleagues showed how exposure to depleting uranium from ammunition jeopardizes children's health (Hon et al., 2015). Both genetic and environmental factors such as irradiation, radiotoxicity, toxins, and chemotherapeutic agents can cause developmental disturbances resulting in tooth anomalies: military veterans from wars in the Balkans and the Gulf war showed chromosomal instabilities (Milacic, 2008; Milacic and Simic, 2009). Although an increased incidence of congenital anomalies and cancer were reported among civilians from conflict regions (Obralic et al., 2004; Alaani et al., 2011), no studies about the impact of uranium exposure on teeth development have ever been published.

Sequence and timing of emergence of primary and permanent dentitions

The sequence of teeth emergence differs among populations. In addition, the rate and sequence of eruption change in the same population over time. The only data available on tooth emergence in Serbian children were published in 1976 (Gvozdenovic-Simovic, 1976). The author reported significant delays in exfoliation time of primary teeth and eruption of permanent teeth in children with malocclusions (narrow maxillary and mandibular arches and a deep bite) when compared with their peers without reported malocclusions. The time of exfoliation and tooth emergence is highlighted in Matiegka`s tables (Łabiszewska-Jaruzelska 1995); and a comparison between chronological and dental age in school children with malocclusions (6-14 years of age) is presented in Table 1.

Table 1. Dental and chronological age comparison in children with malocclusions

Chronological age of participants (years)	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Mean age of participants (months)	81.5	90.43	103.20	114.65	124.98	139.56	151.68	141.63
Dental age (months) (Matiegka)	+10.52	+5.96	-9.02	+4.96	+8.46	+1.37	+5.13	-5.95
Total number of participants (n)	40	128	131	117	79	65	22	19

Since a dental maturity estimation is usually geographically and gender specific, Nikolic et al. used it to assess children`s dental age in comparison to chronological age. In their study, 320 children with mixed dentition were recruited and the chronological and dental age correlation was investigated. Stages in dental formation were assessed by Demirjian`s method (Demirjian and Goldstein, 1973). The correlation between the dental development and chronological age of Serbian children showed 78.6% reliability in boys and 79.6% in girls (Nikolic et al., 2005).

A repeat study was conducted 10 years later involving 686 school children. This time, Demirjian`s and Willems` dental maturity methods were used for comparison (Willems et al., 2001). Both methods showed a discrepancy between dental and chronological age, but Demirjian`s dental age estimation was less accurate in comparison with Willems' method for the Serbian population due to the frequent overestimation of the correlation between dental maturity and chronological age. However, both methods were quite accurate in boys and girls of 4, 9 and 10 years of age. Willems` method offered an acceptable estimation of dental maturity for the Serbian population in general (Djukic et al., 2013). The latest study attempted to find a universal formula for the assessment of dental maturation in the Serbian population. The authors assessed the accuracy of Cameriere`s European dental age estimation formula (Cameriere et al., 2006) in comparison with Willems` method. Willems` formula was more reliable in children older than 13 years of age. Cameriere`s European formula was recommended for children younger than 7 years. No difference in reliability of the two methods was found for the age range of 7 to 13 years (Marinkovic et al., 2018).

Developmental Dental Hard-tissue Anomalies

Developmental disturbances in number, size, shape, position, eruption sequence and structure may occur in some generalized disorders or independent of disorders. Congenital, hereditary, and some local factors can influence tooth formation either before or after birth. The process is multifactorial and the outcome is influenced by the time of disruption along with the magnitude of disruption (Cobourne, 2007).

Studies on skeletal remnants from different historical periods were very popular in the 20th century. For example, Pajevic and Glisic (2017) studied skulls with permanent dentition from the paleoanthropological collection of the Department of Archaeology, University of Belgrade, dated from the

Mesolithic–Neolithic period to medieval times. A total of 666 teeth were evaluated for the presence of anomalies in tooth number, size and structure. The authors reported significantly larger upper first premolars, a lower lateral incisor, and a lower canine in males when compared to females. No abnormality of tooth structure, number or position was observed.

Grga et al. (2017) investigated the dental status of 20 skeletal remnants from the anthropological series of Gomolova in Serbia dated from the mid and early Neolithic periods of the Vinca culture. They gathered extensive information about teeth numbers, structure, caries and periodontal disease, and tooth position – no dental abnormalities in number, shape, position or structure were found.

Tooth Structure Anomalies

Almost twenty years after the NATO intervention in Kosovo, the Faculty of Medicine, Kosovska Mitrovica conducted a study on the prevalence of molar incisor hypomineralization in children who were residents of that region. Seven hundred and twelve school children aged 8 to 10 years were recruited into the study. The authors reported a molar incisor hypomineralization prevalence of 12.2% with lesions predominantly located on the first molars. Also, there was no significant difference in the prevalence of molar incisor hypomineralization in children raised in this particular region exposed to toxic radiation when compared with the prevalence of MIH in children from other world regions (Martinovic et al., 2017).

There have been studies reporting the preventive and restorative treatment of *amelogenesis imperfecta* in Serbian children, but no study had discussed its prevalence. The recent study conducted at the Department of Paediatric and Preventive Dentistry, School of Dental Medicine in Belgrade reported the distribution of various types of *amelogenesis imperfecta* in the sample of 12 affected children with a positive family history: 8 children had hypoplasia, 2 had hypomaturation, and 2 had hypocalcification (Markovic et al., 2010).

The Regional Society for Preventive Dentistry of Vojvodina (a northern region of Serbia) conducted a study on the prevalence of developmental dental anomalies in pre-school and school children in 1979. The prevalence was 4% in pre-school children, 6% in 7-19-year-olds, and only

0.96% in adults (Branovacki, 1979). In the city of Novi Sad (the biggest city in the northern region of Serbia –Vojvodina) the authors reported the prevalence of 6.8% for enamel hypoplasia in patients aged 0-18 years, and 3.9% in adults older than 18 years of age. Also, 8.9% of children and 2.9% of adults had discolorations of enamel without defects. In the same year, the author extended his investigation to three more cities in the same region, and reported a prevalence of 1:12,852 for hereditary enamel hypoplasia (Branovacki, 1979).

Further reports on the prevalence of developmental dental anomalies in four more cities in the northern region of Serbia were conducted by Dzolev (1980) in the epidemiological research within his PhD thesis. Enamel hypoplasia was found in 6.74% of persons up to 35 years of age. The prevalence of discolored enamel without structural breakdown was found in one-fifth of the study population (20.03%). The author reported 30 cases of *amelogenesis imperfecta* in Vojvodina. Furthermore, genetic testing in the families of affected children was undertaken to determine hereditary features, but no chromosomal deviations were observed in these individuals through the study of their karyotypes.

Abnormalities of tooth shape: The incidence of tooth shape anomalies has been poorly documented in the Serbian population. The two studies that determined the prevalence of anomalies of tooth shape were conducted in 1976 (Gvozdenovic-Simovic, 1976; Markovic, 1976). Fusion and gemination were the most frequently observed tooth shape anomalies – 0.5-2.5% (Markovic, 1976). The distribution of tooth shape abnormalities together with malocclusions in 45,056 residents of Belgrade – 3% of the population of Serbia – is presented in Table 2.

Table 2. Distribution of malocclusions in residents of Belgrade in 1976

	Tooth rotation	Abnormalities of tooth shape	Abnormalities of tooth number and tooth structure	Malocclusions with tooth abnormalities
N (%)	7136 (15.8%)	362 (0.8%)	1077 (2.4%)	3348 (7.4%)

Abnormalities of tooth size: Simic et al. (2017) reported on the prevalence of a peg-shaped lateral incisor in 64 Serbian patients with palatally impacted maxillary canines. An atypical lateral incisor was present in 11.2%, and missing in 16.5% of cases. The authors suggested a significant incidence of an atypical or missing lateral incisor in patients with impacted canines. There are no publications on the prevalence of microdontia and macrodontia.

Abnormalities of tooth number: The prevalence of hypodontia in different regions of Serbia ranges from 2.5% to 9.6% (Markovic, 1976). The prevalence of missing upper lateral incisors was 35%, and that of missing lower second premolars was 24% (Zivkovic Sandic, 2016). Genetic studies on etiological factors for hypodontia in the Serbian population displayed missense mutation that could potentially cause hypodontia. More than 50% of patients with hypodontia carried a mutation of either the WNT10A or RUNX2 gene. The frequency of mutation increased in persons with more missing teeth. The mesiodistal width of all teeth in patients with hypodontia was smaller compared to those without hypodontia (Zivkovic Sandic, 2016). Table 3 highlights the results of two studies on the prevalence of hypodontia in Serbian school children in nearby cities in the Eastern region of Serbia – Nis and Knjazevac – where Serbs are the dominant inhabitants (Janosevic et al., 2004; Jankulovski and Filipovic, 2009).

Table 3. Prevalence of hypodontia in the Eastern region of Serbia

Study site (year)	Nis (2004)	Knjazevac (2009)
Number of Children	2470	900
Number of Boys/Girls in the sample	1141/1329	429/471
Age	10-14	9-15
Total hypodontia (%)	6.28	5.34
Hypodontia in upper jaw/lower jaw (%)	32.90/41.21	37.5/54.16
Both jaws (%)	25.81	8.33
Hypodontia of one tooth (%)	40	45.85
Hypodontia in boys/girls (%)	5.34/7.06	4.43/6.16
Hypodontia of lower second premolars (%)	53.76	56.25
Hypodontia of upper lateral incisor (%)	30.65	31.25
Hypodontia of lower central incisor (%)	8.06	6.25

Gaps and Recommendations

Investment for conducting dental epidemiological studies in Serbia has been limited. Epidemiological studies and clinical data collection need time and trained staff, but the high workload of clinical staff doing research might explain the poor data collection (Jeremic et al., 2016). Most patients with tooth abnormalities, difficult malocclusions and dental pathology from all over Serbia are referred to and treated in the five University Dental Clinics in the country. The clinics are often overcrowded and short staffed with little or no time for precise and time-consuming data collection. Therefore, there is a need to organize a systematized survey to generate the necessary data on developmental dental anomalies in Serbia. The constantly growing population of migrants in Serbia brings new challenges to find a universal and accurate dental age maturation estimation method as this has huge implications for future research.

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SUDAN

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Sudan is in eastern Africa, north of the equator and divided by the Sahara Desert. Before its division into North and South Sudan on July 9, 2011, it was the largest country in Africa. The country is known for its tribal and ethnic diversity. In northern Sudan, there are tribes such as Jaliaa, Bedairia, and Shaigia that are Arab in origin. The Nubian tribes are in the far north. Khartoum, the capital of North Sudan, is largely occupied by northern tribes. The eastern region is occupied by Bija and the western region by Kababish and Baggara. Figure 1 is a map of Sudan and its tribal occupancy before it was divided.

Khartoum, Nyala (in the west), and Port Sudan (in the east) are the most populous cities, with nine million inhabitants in Khartoum, 532,183 in Nyala, and 474,373 in Port Sudan. About 56% of the population live in rural areas and 33% in urban areas; 11% are nomads (Census, 2008). Sudan's population is young; about 40 million – more than two-thirds of the population – are under the age of 18 years. Only 3% of the population are over the age of 65 years (Mukhtar and Hassan, 2018).

Sudan's health indicators have improved in recent decades. Infant mortality fell from 120/1000 live births in 1993 to 77/1000 in 2015 (World Health Organization, 2016). The burden of communicable diseases (malaria, tuberculosis, and schistosomiasis), non-communicable diseases, and natural and manmade disasters is still very high (A-Rahman and Jacquet, 2014). About 33% of children under the age of 5 years are moderately

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Figure 1. Sudan and its main tribes before its separation into North and South

underweight, and 12% are severely underweight (Abdel-Tawab and El-Rabba, 2010).

Timing and Sequence of Emergence of Primary and Permanent Dentitions

The timing and sequence of eruption of the primary teeth were determined in a study of 563 Sudanese children, aged 4 to 40 months, who were recruited from health centers in Khartoum and Jabalawliya (Affan and Eid, 2014). Four active phases of tooth emergence were observed. The first phase, the emergence of the central and lateral incisors, occurred within 7.1 months. The second phase was the emergence of the first molars, which occurred in less than one month. The third phase, the emergence of the canines, occurred after a resting period of 3.7 months. The final phase, the emergence of the second molars, occurred after a resting period of 5.3 months.

For both genders, the average time for complete teeth emergence was 17.33 months in the mandible and 15.58 months in the maxilla. Figure 2 illustrates the mean eruption times of the primary teeth. Emergence times of the mandibular and maxillary central incisors and canines, and the maxillary second primary molars were significantly earlier for boys than for girls. Emergence times were not different between the left and right sides of the jaw (Affan and Eid, 2014).

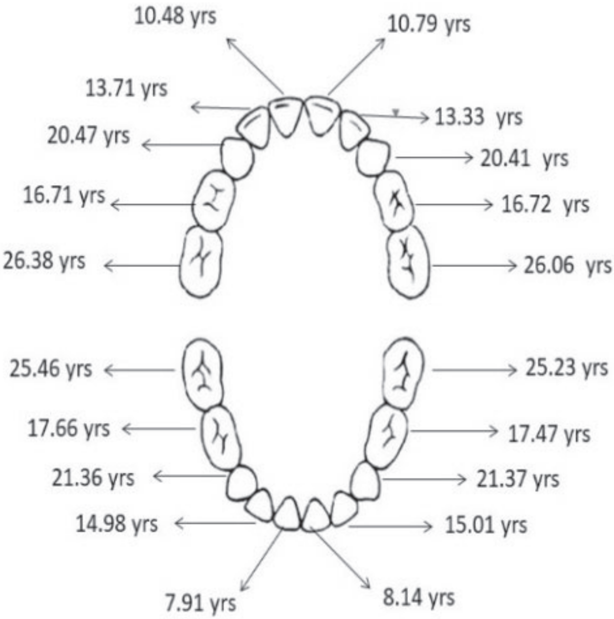

Figure 2: Mean primary dentition eruption times in the maxilla and mandible for males and females

Factors that affect Teeth Emergence

Racial and ethnic: Elamin, Hector and Liversidge (2017) studied the similarities and differences in the timing of tooth formation in two groups of healthy Sudanese, aged 2 to 23 years. The first group, a northern group of Arab origin, consisted of 848 males and 802 females. The second group, a western group of African origin, consisted of 846 males and 402 females. The mean age of teeth emergence was not significantly different between the groups, though there was a trend toward earlier emergence in the western group. Also, the age of teeth emergence was not significantly different between male and female children, a finding suggestive of low sexual dimorphism.

Malnutrition: The effect of malnutrition on developing teeth is not clear, though evidence suggests that severe malnutrition affects dental maturity through environmental insults (Garn et al., 1965). Elamin, Hector and Liversidge (2017) studied the effect of severe malnutrition on the timing of tooth formation in a large representative sample of North Sudan children, aged 2 to 22 years. The subjects were 1,102 males and 1,013 females. The mean ages for most tooth formation, maturation and emergence were not significantly different among ethnic groups. Earlier mean ages were observed in the western group (with no gender differences) for most tooth stages (Elamin, Hector and Liversidge, 2017).

Breastfeeding: Affan and Eid (2014) evaluated the influence of exclusive and non-exclusive breastfeeding for six months on the eruption of maxillary first primary molars. They showed that exclusive breastfeeding for six months was significantly associated with the earlier eruption of maxillary first primary molars. Primary teeth eruption was earlier in boys than in girls, except for the first primary molars. The mandibular central incisors were the first to erupt. No significant differences in eruption time were found between the right and left sides of the jaw, or between exclusive and non-exclusive breastfeeding.

Medical conditions: Abdulgadir (2015) examined teeth in children with type 1 diabetes (mean age 10.85 $\pm$ 2.60 years; 53 females and 27 males; 1,280 teeth). She compared their tooth-emergence time to that of a control group of 81 healthy children (mean age 10.28 $\pm$ 2.81 years; 50 females and 31 males with 1,296 teeth). In the 5-9-year age group, emergence times of mandibular central incisors were significantly earlier in children who had type 1 diabetes than in healthy children.

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Prevalence of Dental Hard-tissue Anomalies

Anomalies of Tooth Number

Hypodontia: Numerous investigators have evaluated hypodontia prevalence in Sudan by reviewing orthopantomographs. In one study, radiographs of 1,069 8-year-old patients (760 females and 309 males) who attended private orthodontic clinics in Khartoum State were reviewed (Hassan et al., 2014). The overall hypodontia prevalence was 5.1%, and it was higher in females than in males. It was also higher in the upper jaw than in the lower jaw. Hypodontia was usually bilateral; when it was unilateral, it was more common on the left side. Teeth commonly missing were the lateral incisors, followed by the second premolars and the canines.

Abdulkareem and Abuaffan (2016) screened the orthopantomographs of 1,225 orthodontic patients (960 females and 265 males) for dental anomalies. The most common lesions were impaction and hypodontia: 8% of patients had hypoplasia, and the teeth most affected were the maxillary second premolars, followed by the maxillary lateral incisors. Teeth in both jaws were equally affected. Unilateral hypodontia was more common in females, and bilateral hypodontia was more common in males.

Abu Affan, and Serour (2014) screened 2,401 students (2,141 females and 260 males) randomly selected from the University of Khartoum medical campus. Of these students, 2.66% had hypodontia, and there was no statistically significant gender difference in its prevalence. Hypodontia was more common in the mandible than in the maxilla; it was also more common in the left jaw than the right jaw. The most commonly affected teeth were the permanent mandibular lateral incisors, followed by the maxillary lateral incisors, the mandibular second premolars, and the maxillary second premolars. Factors associated with hypodontia included the retention of the primary second molar for the premolars and the absence of a permanent successor for the incisors.

The prevalence of hypodontia in institutionalized Sudanese children, aged 6 to 14 years, with Down syndrome was 54.9% (El-Hassan, 2015). It was the most common lesion found, and more prevalent in the mandible than in the maxilla. The prevalence of hypodontia was less in 3-23-year-old West and North Sudanese screened for dental anomalies (0.7% and 2.6%). Only one child had severe oligodontia in the Northern group (Elamin, 2011). The prevalence of hypodontia reported by Khalifa et al. (2012) for Sudanese older than 16 years was 15%.

Supernumerary teeth: The prevalence of supernumerary teeth in a sample of 1,225 Sudanese orthodontic patients was 2.9% (Abdulkareem and Abuaffan, 2016). The most common supernumerary teeth were supplemental teeth, followed by mesodens. Most lesions were unilateral and located in the maxilla. Differences in prevalence were not observed between males and females. El-Hassan (2015) reported a higher supernumerary prevalence (17.6%) in Sudanese with Down syndrome.

Anomalies of Tooth Shape

Peg-shaped lateral incisors: Abdulkareem and Abuaffan (2016) found that 2.6% of Sudanese orthodontic patients who attended private clinics had peg-shaped lateral incisors. There was no difference in prevalence between unilateral and bilateral lesions. Unilateral lesions were more common in males, and bilateral lesions were more common in females; however, these differences were not statistically significant. Amar et al. (2018) found significantly more missing and peg-shaped maxillary lateral incisors in females than in males, and more peg-shaped laterals in the left side than in the right side of the jaw. They did not observe a co-existence of bilateral peg-shaped laterals.

Taurodontism and odontoma: Abdulkareem and Abuaffan (2016) reported a prevalence of 0.2% for taurodontism and odontoma. A higher prevalence of 49% was reported in individuals with Down syndrome (El-Hassan, 2015).

Carabelli trait: Gareeballa (2018) found a high prevalence of the Carabelli trait when he examined 300 Sudanese patients (mean age 29 years) who attended a dental clinic in Khartoum State. Overall, 71.6% of patients had the Carabelli trait on the first molar, and 6.6% had it on the second molar. A bilateral presentation was most common (79.5%), and gender differences were not observed. A rare case of concomitant mesiodens, with cusps of Carabelli on the upper first molars, was reported in a 12-year-old male patient (Elhag et al., 2015); the patient had a palatally erupted mesiodens that caused a rotation of the adjacent upper right central incisor, and prominent cusps of Carabelli on the upper first molars. The cusps were separated from the molar by an accentuated curved groove.

Dental Mutilation

Infant oral mutilation: Oral mutilation is common in Sudan: 22% of North Sudanese and 100% of South Sudanese have been mutilated (Rasmussen et al., 1992). Mutilation is practiced in all socioeconomic groups, but it is most prevalent in the lower groups. In South Sudan, the term "Lugbara tooth extraction" is used to describe the practice. "Haifat" is the term used in North Sudan (Rasmussen et al., 1992). Infant oral mutilation was practiced as a prophylactic measure for teething problems in Nilotic Sudan of Shilluk ethnicity as early as 1932 (Seligman and Seligman, 1965). It involves cutting or inserting sharp, heated objects (penknives, needles, metal blades, and fingernails) into the gingivae to remove the lower cuspid tooth buds. Salt or herbs are applied after the procedure in some cultures (Rasmussen et al., 1992; Willis et al., 2008). Dental anomalies commonly arise from oral mutilation, including enamel defects, tooth loss, mandibular arch size variation, hypoplasia, primary teeth retention, ectopic eruption, displacement, impaction, and odontomas (Rasmussen et al., 1992; Grahame et al., 2000; Willis et al., 2008). Three hundred and ninety-eight 4-8-year-old Sudanese children were examined for the presence of enamel defects on primary canines and its association with past teething problems and their treatment (Rasmussen et al., 1992). From the participants, 65% had experienced teething-related health problems and 22% had been subjected to "haifat". Enamel defects on the buccal surface of the primary canines were seen in 28% of children who had mutilation (Rasmussen et al., 1992).

A more recent study of pre-school children in Khartoum reported a tooth-mutilation prevalence of 10.8% (Elgamri et al., 2018). Mutilation was associated with diarrhea during teething and the lower educational level of the mother. The prevalence of dental anomalies in children who underwent mutilation was 3.1%. The most common lesions were enamel hypoplasia (58.23%), localized enamel opacities (29%), and hypodontia (12.6%). The mandibular canines were the most affected teeth (73.4%). This lower infant oral mutilation prevalence reported in this study is attributed to a shift in the practice of surgical tooth bud removal to the increased use of herbal remedies to resolve teething symptoms (Agbor and Naidoo, 2016).

Ritual tooth extraction: Ritual tooth extraction is most prevalent in South Sudanese tribes – mainly the Dinka and Nuer. It is a symbol of adulthood, beauty, and tribal identity (Willis et al., 2008). In this ritual, anterior teeth (incisors or canines) are extracted immediately after the permanent tooth emerges. The procedure is performed by someone who is valued and chosen by the tribal community. A small, knife-like, instrument is inserted between the central incisors and is moved from side-to-side to luxate the teeth. Then, the instrument is moved to the lingual side of the incisors to separate the gingival tissues from the roots. With a final upward motion, the tooth is brought out. The entire process is performed without anesthesia. Khalifa et al. (2012) reported that 5% of a hospital-based population from various ethnic backgrounds were missing teeth as a result of ritual extraction. Ritual extractions were most common in patients from southern tribes, and most missing teeth were in the lower anterior jaw.

Dilaceration: Amailuk and Grubor (2008) reported a rare case of an erupted, compound, odontoma that was associated with a malformed and dilacerated maxillary left lateral incisor in a 15-year-old immigrant boy. He also had a malformed right lateral maxillary incisor and missing central incisors. As a child, while living in Africa, he underwent a traditional extraction of his primary teeth.

Gaps and Recommendations

In Sudan, research on dental anomalies is limited to the capital city of Khartoum. Studies are needed to determine the prevalence of dental anomalies throughout the Sudanese population. Also, existing studies have used different methods for data collection and statistical analyses; hence, they have produced disparate results. Longitudinal studies could provide valuable information about risk factors for dental anomalies; however, ethical issues related to the examination of human subjects make this approach challenging.

The Ministry of Health should adopt a medical record system that includes dental and oral health data for every child in the country. These records should specifically include data about teeth eruption and dental anomalies. Such records could guide future research on the prevalence, risk factors, and presentations of various dental anomalies.

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TAIWAN

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Background Information on Taiwan

Taiwan is an island in East Asia, surrounded by the North Pacific Ocean, the Taiwan Strait, and the East China Sea. It has an area of 36,193 km^2 and a population of 23.5 million, of which 95% are Han Taiwanese. The percentage of the population under 14 years old is 13.12%, and the total fertility rate is 1.18. Figure 1 shows Taiwan, its territories and its relationship with neighboring countries.

Also, 11.46% of Taiwanese elementary school children are obese, and 80% of the population do not take calcium supplements (Ministry of Health and Welfare, 2012). The Tsao-tun area had its water fluoridated at a level of 0.6 ppm from 1972 to 1984. This was accompanied by a 66.6% decrease in caries prevalence when compared with the caries prevalence in a non-fluoridated area. Currently there is no water fluoridation program in any area in Taiwan.

Timing and Sequence of Emergence of Primary Dentition

Lu et al. (2010) assessed differences in the time of emergence of the primary teeth between children who were born pre-term and full-term. At

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Figure 1. Map of Taiwan

the chronological age of 6-11 months, children who were born pre-term had a slightly delayed emergence of primary teeth compared to that of full-term birth children. However, when the age of the pre-term children was corrected for the early birth, there was no significant difference in the time of emergence between the two groups. Also, no specific neonatal or nutritional factors were found to influence body length, body weight, and head circumference.

Natal teeth: The prevalence of natal teeth is low in Taiwan. Hsu et al. (2014) screened 1,043 newborns at a medical center for natal teeth and found that only three of them were born with natal teeth, a prevalence of 0.29%.

Other disturbances of primary tooth emergence: There are no epidemiological surveys to determine the prevalence of tooth emergence disorders of the primary teeth. There are, however, case reports on ankylosis of the primary molars (Tang et al., 2016; Huang and Hung, 2016) and primary eruption failure (Siao et al., 2015; Chang et al., 2016).

Delayed exfoliation of the primary teeth associated with cleidocranial dysplasia also has been reported (Hsu et al., 2002).

Timing and Sequence of Emergence of Permanent Dentition

Liu (2004) examined 271 children to determine the sequence of emergence of the permanent first molar and the mandibular incisor. She found a significant difference in the timing of emergence of these teeth between Taiwanese boys and girls: in 51% of boys and 46% of girls, mandibular incisors emerged before the first permanent molars. The average age of emergence of the first permanent tooth was 6 years and 1.6 months. The average age of emergence of the first permanent tooth was 1.6 months later for boys than for girls.

Impacted permanent mandibular second molars: Fu et al. (2012) screened 21,580 healthy patients, including 10,668 males and 10,912 females, who attended three dental clinics in Kaohsiung, in the southern part of Taiwan, between 1999 and 2010 for impacted permanent mandibular second molars. Only 142 patients were found with the lesion, giving a prevalence of 0.65%. No gender difference was observed. The prevalence was slightly higher than that reported in non-Asian countries (Varpio and Wellfelt, 1988; Bondemark and Tsiopa, 2007). It was suggested that larger tooth size among Chinese rather than among Caucasian populations may partly explain the higher prevalence of an impacted permanent mandibular second molar in the Chinese population (Cho et al., 2008).

Developmental Dental Hard-tissue Anomalies

Dental anthropologists report that the dental traits of Taiwanese are more like those of Japanese than of Central American Indians, South American Indians, and Caucasians (Huang et al., 1992). Compared to Japanese, Central American Indians, South American Indians and Caucasians, Taiwanese males had generally a smaller crown size, especially of the upper canine, lower central incisor and first molar (Huang et al., 1991). In Taiwanese females, the lower first molar was smaller than that of Central and South American Indians, while the upper first premolar, lower canine and lower central incisor were larger than those of Japanese. The upper lateral incisor was larger than that of South American Indians, while the upper central incisor was smaller and the upper first premolar was larger than the corresponding teeth of North American Caucasians (Huang et al., 1991).

In the permanent dentition, the prevalence of shovel-shaped maxillary anterior teeth was high, while the prevalence of the Carabelli cusp of the maxillary molars, was low. Also, the lower premolars of Taiwanese subjects had a more prominent lingual cusp, interstitial cusp, central prominence, and occlusal groove (Huang et al., 1992).

Fused/geminated primary teeth: Chen et al. (2007; 2010) screened 3,387 children from 42 randomly selected kindergartens in Taiwan for fused/geminated primary teeth. The prevalence was 2.8 %, with no sex predilection. A higher prevalence was found in northern Taiwan than in middle and southern Taiwan. The most commonly affected teeth were the mandibular lateral and canine, a pattern that had been observed by Wu et al. (2010) in the southern Taiwanese population. Also, 79.1% of the fused/geminated primary teeth presented unilaterally, while 11.8% had symmetrical bilateral fused primary teeth. The ratio of fusion to gemination was 36.5:1, which suggests more fusion than gemination in Taiwanese children.

Lin et al. (2012) reported a case of fusion of the maxillary primary central incisor and lateral incisor, while Chen et al. (2003) reported a case of bilateral presentation of a fused maxillary primary central incisor and lateral incisor. Wu et al. (2010) screened 7,868 dental records of children under the age of 17 years. The prevalence of double primary teeth was 0.72%. Also, 56% of the children who had fused/geminated primary teeth had the same tooth anomalies in the permanent successors. Lin et al. (2014) reported a rare case of bilateral fused mandibular primary lateral incisors and canines, with the succeeding permanent lateral incisors and canines also fused bilaterally.

Dens evaginatus: Tseng and Shieh (2004) screened 2,642 elementary school children aged 10 to 13 years residing in Kaohsiung City. The prevalence of dens evaginatus was 5.41%, with no significant gender difference. Teeth affected were the mandibular second premolar (50.79%), the mandibular first premolar (33.73%), the maxillary second premolar (11.11%), and the maxillary first premolar (4.37%). In addition, among the 143 children affected, 23.78%, 32.87%, 11.19% and 23.08% had one, two, three and four premolar teeth affected respectively. A rare case series of talon cusp in primary dentition was reported by Chen and Chen (1986).

Supernumerary teeth: Lung (2008) screened 6,423 patients who had panoramic radiographs taken between 2006 and 2007 in Kaohsiung Medical University Hospital and reported a prevalence of 2.6% (167 patients). Among the 167 patients, there were 248 supernumerary teeth. Most of the supernumeraries (67.7%) presented unilaterally, a prevalence like those reported by Chen et al. (2006) and Yen et al. (2015). About a third of the patients had two supernumerary teeth, but less than 0.45% had more than two. Multiple supernumerary teeth are often associated with systemic diseases, such as cleidocranial dysplasia (Su et al., 2006; Tsao et al., 2007). Yang and Lin (2006) reported the prevalence of mesiodens as 3.29%.

The studies by Chen et al. (2006), Yang and Lin (2006), Lung (2008) and Yen et al. (2015), conducted in four medical centers in Taiwan, reported a total of 1,275 supernumerary teeth in 947 patients. There was a male predilection, with the male to female ratio ranging from 3.2-3.7:1. The teeth were conically shaped in 47.98% to 82.25% of cases, unerupted in 79.84% of cases, and palatally located at the central incisor region in 73.48% to 95% of cases. Some studies found that the supernumerary teeth were inverted in 52.75% to 58% of cases (Chen et al., 2006; Yang and Lin, 2006; and Yen et al., 2015), while Lung (2008) found more normally oriented teeth (59.27%). Also, 14% of those vertically oriented teeth had erupted (Chen et al., 2006). Mandibular supernumerary teeth (Liu and Chang, 2006) as well as a supplemental maxillary left primary first molar (Chuang et al., 2006) were observed.

The morphology of root shape and canal in permanent teeth: Wang et al. (1985) screened 1,026 teeth for concavity on the root surface and found that the prevalence of root concavity was higher in a maxillary tooth than in the corresponding mandibular tooth. The concavity often involved the cervical third and middle third of the root, and usually involved the distal third of the root and the furcation areas.

A review of cone-bean computed tomography of Taiwanese patients found more second canals in the mesiobuccal root of the maxillary first molar than in the maxillary second molar (Tseng, 2016; Su et al., 2016). Also, the canal configuration of the roots of the maxillary second molars was more complex than that of the first molars. The mesiobuccal roots of the maxillary molars had more variation than the roots of other teeth (Lin et al., 2017).

Gaps and Recommendations

Data on tooth emergence and developmental dental hard-tissue anomalies are sparse in Taiwan, and there are no nationally representative data on these issues. In view of the significance of these kinds of data, it is important that a comprehensive national survey is conducted.

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TANZANIA

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Background Information on Tanzania

Tanzania, East Africa, is bordered by Kenya, Uganda, Mozambique and the Indian Ocean, with a total land area of 945,000 square km. The terrain consists of lowland plains along the coast, a central plateau and highlands in the north and south. Kilimanjaro, the highest mountain in Africa, lies to the north-east of Tanzania, with an altitude of 5,895 m. Tanzania also has Lake Victoria, the largest lake in Africa (CIA, 2018), and Lake Tanganyika, the second deepest lake in the world, forming its western boundary (CIA, 2018). Figure 1 shows details of the political structure of Tanzania.

The country is home to about 53 million people, of whom 6.7% are under one year of age and 19.2% are under five years. Tanzania's political stability and macroeconomic management have allowed its economy to grow at an average GDP growth rate of 7 per cent over the past decade (World Bank, 2013). The economy is driven by robust growth in the tourism, mining, trade and telecommunications sectors. Despite these gains, poverty remains prevalent and persistent in Tanzania, with 68 per cent of the population living below the international poverty line of $1.25 per day (UNICEF, 2015). Poverty and food insecurity are the main drivers of chronic undernutrition, which is responsible for more than 130 child deaths every day, making it the greatest contributor to the deaths of under-five-year-olds in the country (UNICEF, 2015). The Tanzania Demographic and Health Survey reported that 14% of all Tanzanian children are underweight, and 3% are severely underweight.

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Figure 1: Map of Tanzania

The proportion of children who are underweight is greater in rural than in urban areas (15% vs. 9%). In addition, 34% of children are stunted, and 12% are severely stunted. Stunting increases with age, peaking at 44% among children aged 24-35 months. Stunting affects more rural than urban children (TDHS – MIS 2015/16). Stunting is attributed to a combination of factors, including maternal malnutrition, inadequate infant feeding practices, poor quality of health care, and poor hygiene (FAO, 2018).

Most people living in Kilimanjaro, Arusha, Manyara, Singida, Shinyanga, Simiyu, Mwanza, Geita and Mara regions drink water with fluoride levels above the World Health Organization guidelines for fluoride in drinking water of 1.5 mg-F/l. As a result, some people have developed fluorosis problems ranging from mottled teeth to crippling fluorosis. The high concentrations of fluoride in the drinking water come from the alkaline volcanic activity associated with the geologic features of the rift valley. According to Jha et al. (2011) groundwater is the major source of fluoride for most people in Tanzania. Other sources are tea and air pollution.

Uvulectomy and canine follicle removal in infants and children are practices that occur in certain cultures (Hiza and Kikwilu, 1992). Tooth-bud extraction by traditional healers has been reported in various parts of Tanzania for decades (Hiza and Kikwilu, 1992). Traditional healers, in their attempts to find the causes of diarrhea, fevers and other diseases of childhood, associate gingival prominences in the areas corresponding to unerupted deciduous canines with these illnesses. Underneath these prominences are developing tooth buds. Traditional healers dig up the developing tooth buds, hoping to cure the childhood diseases. This practice is compounded by access to ready clients for the traditional healers due to a weak health care delivery system, and an ignorant society. Desperate mothers with sick children and limited options take their sick babies to traditional healers, who perform this brutal exercise without anesthesia and under unsterile conditions. This practice has been associated with developmental defects of the permanent teeth underlying the removed primary tooth buds (Hiza and Kikwilu, 1992), infections, loss of blood and even failure of the destroyed permanent teeth to erupt.

Timing and Sequence of Emergence of Primary Dentition

The mean times of teeth emergence in children in Tanzania are highlighted in Table 1. Variability in the age of emergence of primary teeth is relatively small, with standard deviations of 2 to 3 months. On average, the emergence of primary teeth begins at about the age of 6 months for the mandibular central incisors and ends at the age of about 30 months for the maxillary second molars. Thus, in most children, the total period of eruption of primary dentition spans about two years.

Timing and Sequence of Emergence of Permanent Dentition

The mean emergence times of permanent teeth are highlighted in Table 2. Variability in the timing of emergence of permanent dentition is much greater than the variability of the primary dentition. The first molars and incisors have the least variability in their timing of emergence, while the canines and premolars have the highest variability in their timing. The emergence of the permanent dentition begins with the mandibular central incisors at 6 years of age and ends with the maxillary second molars at 12 years. Thus, the total period of emergence of the permanent teeth (exclusive of the third molars) spans about 6 years. In both sexes, a tendency for grouped teeth emergence was observed, with the teeth within a group showing similar mean times of emergence. The following groups are distinguishable: the first mandibular molars and the mandibular central incisors; the maxillary central and mandibular lateral incisors; the mandibular canines and first premolars; and the maxillary canines and second premolars and second molars.

Table 1. Mean emergence times (in months) for each sex

Tooth	**Female**		**Male**	
	Mean age of tooth emergence	Standard deviation	Mean age of tooth emergence	Standard deviation
Mandible				
Central incisor	7.5	2.0	8.0	3.0
Lateral incisor	11.5	2.5	13.0	3.5
Canine	19.0	3.0	19.5	4.0
First molar	16.0	2.0	16.5	3.0
Second molar	24.5	4.0	25.0	5.0
Maxilla				
Central incisor	10.0	2.0	10.0	3.0
Lateral incisor	12.5	3.0	13.0	3.5
Canine	19.0	3.0	19.5	4.0
First molar	16.0	2.5	16.5	3.0
Second molar	24.5	4.0	25.5	5.0

Source: unpublished data, Masumo, Bårdsen and Åstrøm, 2013

Table 2. Mean emergence times (in years) of permanent teeth for each sex

Tooth	Female		Male	
	Mean age of tooth emergence	Standard deviation	Mean age of tooth emergence	Standard deviation
Mandible				
Central incisor	6.9	1.0	6.8	1.2
Lateral incisor	7.9	1.2	7.9	1.2
Canine	10.5	1.3	11.4	1.3
First premolar	11.2	1.2	10.9	1.4
Second premolar	11.5	1.0	11.3	1.3
First molar	5.2	1.2	5.1	1.2
Second molar	11.9	1.2	12.2	1.2
Maxilla				
Central incisor	7.5	1.2	7.7	1.2
Lateral incisor	8.5	1.1	8.6	1.2
Canine	11.2	1.1	11.6	1.2
First premolar	10.5	1.2	10.7	1.3
Second premolar	12.3	1.0	11.5	1.3
First molar	5.4	1.1	5.1	1.2
Second molar	12.3	1.0	12.2	1.2

Source: Mugonzibwa et al., 2002

Developmental Dental Hard-tissue Anomalies

Tooth development may be disturbed at various stages of morphogenesis, and the result depends on the timing and the type of insult (Robert Moshy, Singh Sohal and Chindia, 2017). Variations in the number, shape, and size of teeth are commonly linked. Hypodontia is often associated with microdontia or peg-shaped teeth. These result from an inhibition of early morphogenesis, which leads either to a complete arrest in development or to small teeth, depending on the type of tooth and the extent of disruption. The most commonly missing teeth are the third molars, second premolars, and maxillary lateral incisors. It is believed that these teeth are affected because they are the last teeth to develop from the respective dental placode (Robert Moshy, Singh Sohal and Chindia, 2017).

A cross-sectional survey conducted in 1994 among 2,192 children residing in nine regions in Tanzania aged 1 and 4 years, reported a low prevalence of enamel hypoplasia in the regions that have high levels of fluoride in drinking water. The prevalence of enamel hypoplasia ranged from 2.7% (95% CI 0.8% to 6.3%) in Singida, with 5.9 mg/l fluoride in drinking water, to 37.2% (95% CI 33.0% to 41.0%) in Morogoro, with 0.6 mg/l (Matee et. al., 1994). Table 3 shows the prevalence of enamel hypoplasia in the regions of Tanzania by concentrations of fluoride in drinking water. The prevalence of enamel hypoplasia was similar in Iringa and Mwanza, although the two regions had different concentrations of fluoride in drinking water. Thus, factors other than fluoride concentrations have likely contributed to the difference in prevalence of enamel hypoplasia in children from the Morogoro and Iringa regions, which have similar fluoride concentrations in drinking water.

Table 3. Prevalence of hard-tissue anomalies and mean fluoride content in drinking water in various regions of Tanzania

Region	Fluoride (mg/l)	Type of hard-tissue anomaly	Prevalence of hard-tissue anomalies Prevalence; 95% Confidence Intervals
Iringa	0.5	Linear enamel hypoplasia	11.8%; 7.7% to 17.2%
Mbeya	0.7	Linear enamel hypoplasia	6.1%; 3.1% to 10.5'%
Tanga	0.9	Linear enamel hypoplasia	11.1%; 7.1% to 16.4%
Songea	-	Linear enamel hypoplasia	6.4%; 3.4% to 10.8%
Singida	5.9	Linear enamel hypoplasia	2.7%; 0.8% to 6.3%
Dodoma	1.5	Linear enamel hypoplasia	5.7%; 3.0% to 10.3%
Mwanza	3.4	Linear enamel hypoplasia	11.4%; 8.4% to 16.9%
Moshi	1.9	Linear enamel hypoplasia	6.0%; 3.1% to 10.3%
Morogoro	0.6	Linear enamel hypoplasia	37.2%; 33.0% to 41.0%

Source: Matee et al., 1994

The results of another cross-sectional study that assessed the association of early-life events with developmental defects of enamel in primary teeth among 6-36-month-old children in the Manyara region of Tanzania are highlighted in Tables 4 and 5 and Figure 1. The prevalence of developmental enamel defects was 33.3%. Diffuse opacity was the most common type of defect (23.1%), followed by enamel hypoplasia (7.6%), and demarcated opacity (5.0%). Most children presented with three or more teeth affected by enamel hypoplasia (Masumo, Bårdsen and Åstrøm, 2013).

Table 4. Prevalence of children with single and multiple hard dental tissue anomalies

Number of teeth affected	Demarcated opacity % (n)	Diffuse opacity % (n)	Enamel hypoplasia % (n)	Developmental defect of the enamel % (n)
No tooth	95.0 (1160)	76.9 (939)	92.1 (1124)	66.7 (814)
1 tooth	2.7 (33)	0.9 (11)	1.7 (21)	4.7 (57)
2 teeth	2.0 (24)	12.4 (151)	1.9 (24)	15.2 (186)
≥3 teeth	0.3 (4)	9.8 (120)	4.3 (52)	13.4 (164)

Source: Masumo, Bårdsen and Åstrøm, 2013

The prevalence of developmental defects of enamel by the type of tooth is depicted in Table 5. Masumo, Bårdsen and Åstrøm (2013) found that the prevalence of demarcated opacities was higher in the central incisors of the upper jaw (2.3% to 3.5%). The prevalence of diffuse opacities was highest in the upper central incisors (24.4% to 24.6%) and lowest in the lower central incisors (2.3% to 2.4%). The prevalence of hypoplasia was highest in the upper canines (5%) and lowest in the lower central incisors (1%). The prevalence of developmental defects of enamel reported in this study might be underestimated as only lesions observed on the buccal surfaces were reported.

Table 5. Prevalence of developmental defects of enamel according to tooth type

Type of defect	Tooth % (n)									
	55	**54**	**53**	**52**	**51**	**61**	**62**	**63**	**64**	**65**
Normal	89.7 (200)	90.7 (485)	87.1 (330)	88.2 (696)	70.9 (713)	69.3 (692)	88.0 (690)	86.5 (326)	89.1 (476)	89.1 (197)
Demarcated opacities	0.0 (0)	0.0 (0)	0.0 (0)	0.9 (7)	2.3 (23)	3.5 (35)	0.3 (2)	0.0 (0)	0.0 (0)	0.0 (0)
Diffuse opacities	8.5 (19)	7.1 (38)	7.7 (29)	8.9 (70)	24.4 (245)	24.6 (246)	9.1 (71)	8.5 (32)	8.2 (44)	8.6 (19)
Hypoplasia	1.8 (4)	2.2 (12)	5.3 (20)	2.0 (16)	2.3 (23)	2.4 (24)	2.7 (21)	5.0 (19)	2.6 (14)	2.3 (5)
Total	100 (223)	100 (535)	100 (379)	100 (789)	100 (1004)	100 (997)	100 (784)	100 (377)	1100 (534)	100 (221)
Tooth	**85**	**84**	**83**	**82**	**81**	**71**	**72**	**73**	**74**	**75**
Normal	89.6 (224)	90.0 (479)	85.4 (310)	95.4 (661)	95.8 (1162)	95.6 (1158)	94.9 (654)	86.2 (306)	88.8 (478)	90.4 (225)
Demarcated opacities	0.0 (0)	0.0 (0)	0.3 (1)	0.2 (2)	0.9 (10)	0.9 (10)	0.2 (2)	0.6 (2)	0.2 (1)	0.0 (0)
Diffuse opacities	7.6 (19)	7.0 (37)	7.7 (28)	2.5 (17)	2.3 (28)	2.4 (29)	2.9 (20)	7.9 (28)	8.2 (44)	7.2 (18)
Hypoplasia	2.8 (7)	3.0 (16)	6.6 (24)	1.9 (13)	1.1 (13)	1.2 (14)	1.9 (13)	5.4 (19)	2.8 (15)	2.4 (6)
Total	100 (250)	100 (532)	100 (363)	100 (693)	100 (1213)	100 (1211)	100 (689)	100 (355)	100 (538)	100 (249)

Source: Masumo, Bårdsen and Åstrøm, 2013.

Maxillary central incisor: 51 and 61; Mandibular central incisor: 71 and 81; Maxillary lateral incisor: 52 and 62; Mandibular lateral incisor: 72 and 82; Maxillary canine: 53 and 63; Mandibular canine: 73 and 83; Maxillary first molar: 54 and 64; Mandibular first molar: 74 and 84; Maxillary second molar: 55 and 65; Mandibular second molar: 75 and 85

Figure 2 shows the frequency distribution of enamel hypoplasia according to tooth type in low and normal birth weight children (Masumo, Bårdsen and Åstrøm, 2013). The prevalence of enamel hypoplasia was higher in children with low birth weight when compared with children with normal birth weight. In the low birth weight group, the upper left canine was the most affected, while the mandibular right lateral incisor was the least affected. In the normal birth weight group, the mandibular left canines were the most affected, while the mandibular central incisor was the least affected.

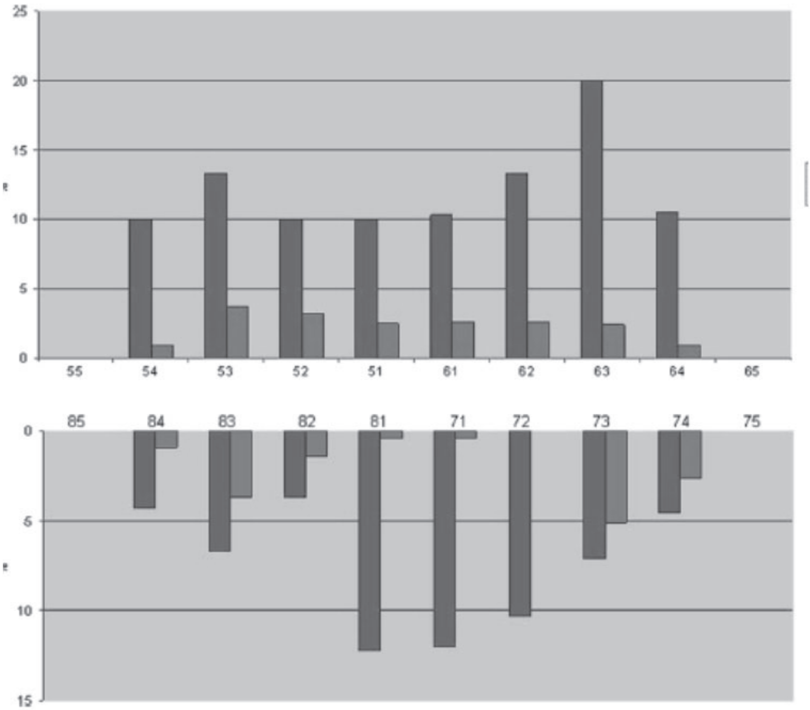

Figure 2. Frequency distribution of enamel hypoplasia according to tooth type in low and normal birth weight children (Source: Masumo, Bårdsen and Åstrøm, 2013)

Gaps and Recommendations

Tooth development disturbances, such as morphologic aberrations and severe mineral disturbances, can delay or inhibit tooth emergence, possibly because of defects in the coronal follicle. Tooth anomalies of dental hard tissue have not been thoroughly studied in Tanzania. Moreover, there is limited retrievable information on factors that could predispose to tooth developmental dental anomalies. However, evidence from other countries suggests that determinants of dental anomalies include socioeconomic conditions, safe water, access to health care services and good nutrition. As Tanzania is transitioning to a middle-income country, efforts should be made to tackle the factors associated with dental anomalies. This effort will entail improving access to safe water with optimal levels of fluorides, addressing poverty, and overcoming extreme hunger, which are factors known to hamper tooth development. In addition, further studies are required to establish the prevalence and factors associated with hard dental tissue anomalies so that evidence-based interventions can be implemented.

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TURKEY

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Background Information on Turkey

Turkey is a country that connects Europe and Asia geographically (Figure 1). Throughout its history, it has acted as both a barrier and a bridge between the two continents. It borders the Black Sea to the north, the Aegean Sea to the west, and the Mediterranean Sea to the south, where Cyprus lies. Turkey also contains the Sea of Marmara. The capital is Ankara, and its largest city and seaport is Istanbul. The estimated population is 80,810,525 inhabitants, of which 19,033,488 are children aged 0-15 years (Turkish Statistical Institute, 2017). Turkey has 29,417 dentists (Turkish Dental Association, 2016).

Epidemiology of Predisposing Factors for Dental Anomalies

Dental anomalies are common in the world. They can be influenced by environmental factors and genetics (Almaz, Sönmez and Oba, 2017). Investigations of dental anomalies have reported different prevalences in various ethnic groups (Kırzıoğlu et al., 2009; Şener, Bozdağ and Ünlü, 2011; Jalevik et al., 2001; Dang, Constantine and Anderson, 2017).

Consanguineous marriage is a risk factor for genetic dental anomaly syndromes. In Turkey, where 25% of marriages are consanguineous, genetic dental diseases are common. It is estimated that more than six thousand Turkish patients have syndromic dental diseases attributable to consanguineous marriage (Turkish Statistical Institute data). These syndromes, and their dental findings, are mostly reported as case reports

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(Yavuz et al., 2002; Ayna et al., 2008; Kanat et al., 2013; İnce et al., 2016).

Figure 1. Map of Turkey

Environmental factors associated with the development of dental anomalies include: history of dental trauma, duration of infectious diseases in childhood, and exposure to radiotherapy and chemotherapy. Turkey has a high frequency of traumatic injuries; however, data about the frequency of dental trauma in various regions of Turkey are limited or unreported. Tumen et al. (2017) reported a 4.6% traumatic dental injury prevalence for children aged 8-12 years; Zengin et al. (2015) reported a 4.4% prevalence in 11-20-year-olds; and Koruyucu et al. (2018) reported a 3.5% prevalence in 6-12-year-olds. Eyüboğlu et al. (2009) studied traumatic dental injuries over a six-year period and reported an incidence of 4.9%.

It is thought that childhood disease in the first three years of life can lead to dental anomalies, especially molar incisor hypomineralization. Implicated diseases include upper respiratory tract infection, bronchitis, pneumonia, asthma, chickenpox, otitis media, tonsilitis and rubella (Jalevik et al., 2001). The relationship between dental anomalies and childhood disease in Turkey has not been studied.

Dental abnormalities, such as delayed dental development, microdontia, hypoplasia, agenesis, V-shaped root, and shortened root can also result from many factors, including exposure to chemotherapy and radiotherapy in early childhood. About 2,500-3,000 new cases of cancer occur in 0-14-year-olds each year in Turkey (Kutluk, 2009). This will likely lead to an increase in the prevalence of dental anomalies resulting from its management.

Timing and Sequence of Emergence of Permanent Dentition

The sequence of tooth eruption in humans consists of three periods (Marks and Schroeder, 1996). During the first period, the permanent first molar incisors emerge. In the second period, the other primary teeth exfoliate and are replaced, and the second permanent molar emerges. The third molars emerge in the last period. There are few studies on the sequence and timing of dental emergence in Turkey.

Bayrak et al. (2012) clinically identified the timing and sequence of permanent teeth emergence in male and female children in Samsun, Turkey. The study population consisted of 1,491 children aged 5-15 years (51.8% females and 48.2% males). Tooth emergence started at 75 months (mandibular central incisor) and ended at 133 months (maxillary second molar) for females. For males, emergence started at 76 months (mandibular central incisor) and ended at 133 months (maxillary canine). Most teeth emerged earlier in females than in males, with the differences in the mean age of tooth emergence ranging from 1-13 months.

Wedl et al. (2004) determined the timing of permanent tooth emergence through a longitudinal study conducted in the Aegean city of Izmir. Study participants were 1,046 male and 1,055 female patients between the ages of 3.98 and 24.91 years. The authors found significant differences between the eruption times of males and females, which were attributed to differences in sexual maturity of the genders at specific ages. When they compared their results with those of other international populations (Finland and USA) they found no substantial differences in the sequence and timing of the permanent dentition and the maximum difference for the eruption of a single tooth was 1 year.

Tokmak et al. (2007) evaluated the emergence timing interval of the first permanent molar in 5-6-year-old children. The eruption time of the first permanent molar was 74.88 ± 5.95 months in the mandible and 75.87 ± 6.25 months in the maxilla for females. For males, it was 74.51 ± 5.19 months in the mandible and 76 ± 7.97 months in the maxilla. Significant differences in tooth emergence time were not observed between the genders, between the mandibular and maxillary first molars, or between the left and right sides of the jaw.

Karadayı et al. (2012) analyzed data regarding third molar development and eruption in the Turkish population for dental-age estimation. A total of 768 dental panoramic radiographs of 394 females and 374 males, aged 8-22-years-old, were examined. The mean age of mandibular third molar emergence was 16.79-17.27 years in males and 17.64-18.22 years in females. For both genders, the mean age for complete crown calcification was about 15 years. Also, third molars were likely to appear at the age of nine years and complete development by the age of 21 years for both males and females.

Karataş et al. (2013) reported the chronologic age of third molar mineralization in Turkish children from the southwest Eastern Anatolia region, using the Demirjian staging method. For all of the third molars there were no significant differences in the age of mineralization between males and females. For both genders, the dental age was lower than the chronological age. Males reached the developmental stages earlier than females. These findings were similar to those of Orhan et al. (2007) and Sisman et al. (2007), who also used the Demirjian method to estimate chronologic age based on the stages of third molar development for Turkish populations.

Altunsoy et al. (2015), reported that the Demirjian method is not suitable for western Turkish children. The dental age results of Turkey's northern, northeastern and eastern studies were reported as being more advanced in dental maturity than western region. These differences have been attributed to regional differences in climatic, genetic, hormonal and nutritional factors which can affect the development of dental age within the same country.

Erdem et al. (2013) also found that the Demirjian standards were not suitable for northwestern Turkish children; they proposed that the determination of dental development should be based on population-specific standards. In the same way, Tunç and Koyuturk (2008) found the dental age of Turkish children to be overestimated using the Demirjian method. In contrast, Gungor et al. (2015) reported that the Demirjian method was suitable for southern Turkish children, though a revision was needed for some age groups.

Miloglu et al. (2011) assessed whether the Nolla method was appropriate for the determination of the dental age in Turkish children. They reported that girls had a delayed formation of permanent teeth, and there was a significant difference between the estimated dental age and the chronologic age. In contrast, a significant difference was not observed between the dental age and chronologic age of boys. Thus, the Nolla method was able to identify gender differences in tooth formation and eruption in Turkish children.

Developmental Dental Hard-tissue Anomalies

The prevalence of dental anomalies was investigated in various populations and ethnic groups (Aren et al., 2015; Aglarcı et al., 2016; Almaz, Sönmez and Oba, 2017; Dang, Constantine and Anderson, 2017; Guven et al., 2017; Jamshidi et al., 2017; Baron et al., 2018). However, differences in several factors such as race, sampling methods and diagnostic criteria, have led to inconsistent results between, and within, populations. Published studies and case reports of dental anomalies in Turkey are summarized in Tables 1 and 2.

Most studies reported on anomalies of tooth number, size, and shape. For example, Bilge et al. (2017) reviewed the panoramic radiographs of 1,200 patients and found that the prevelance of tooth number anomalies was 17%, with a hypodontia prevalence of 13.8%. Also, the prevalence of tooth size anomalies was 8.2%, and the prevalence of tooth-structure anomalies was 0.2%, with that of amelogenesis imperfecta being 0.08%. The prevalence of tooth-position anomalies was 60.8%; tooth impaction prevalence was 45.5%. The prevalence of tooth-shape anomalies was 27.8%. This included fusion-gemination (0.08%), dilaceration (16.3%) and taurodontism (11%).

Table 1 highlights the prevalence of various dental anomalies by different authors. The prevalences reported vary significantly with no observed trends. Only one study reported a prevalence of dens evaginatus (6.2%), enamel hypoplasia (0.4%), peg-shaped teeth (2.15%). transmigrant teeth (0.16%) and root anomaly (0.44%). There are no data on dentin dysplasia and tooth displacement.

Tunc, Bayrak and Koyuturk (2011) compared dental development in a group of children with mild-to-moderate hypodontia to determine whether the severity of hypodontia has an effect on dental development. Seventy children (43 girls, 27 boys) with hypodontia, aged 5.3-12.5 years, were matched by race, age, and sex with 140 healthy controls. Dental ages were calculated by a modified Demirjian's dental-age estimation method. Children with mild-to-moderate hypodontia had statistically significant delayed dental development by a few months compared with those without hypodontia.

Molar-incisor Hypomineralization

There is limited research about the prevalence of molar-incisor hypomineralization in Turkey. Koruyucu, Özel and Tuna (2018) examined 1,511 children (760 boys, 751 girls), aged 8 and 11 years. Of the 215 children found to have molar-incisor hypomineralization, 18.2% were 11 years old, and 9.9% were 8 years old. Complications during the mother's pregnancy, birth prematurity, average breastfeeding period, diarrhea frequency, digestive system diseases, asthma, frequent high fever, ear infection, renal failure, rubeola, chickenpox, and parotitis were found to be significantly associated with molar-incisor hypomineralization ($p < 0.001$).

Sonmez, Yıldırım and Bezgin (2013) examined 4,049 children aged 7-12 years (2,029 girls, 2,020 boys) in Ankara, Turkey. Molar-incisor hypomineralization was detected in 7.7% of the group. Chickenpox (29.3%), frequent fever (26.1%), measles (14.7%), prematurity (7%), pneumonia (6.3%), and gastrointestinal problems (3.9%), before the age of four years were associated with molar-incisor hypomineralization.

Tunc et al. (2013) examined 105 children (59 girls, 46 boys) aged 7-11 years with severe molar-incisor hypomineralization and a similar cohort of 105 healthy children in Samsun, Turkey. Significant differences in the time of tooth emergence between children with and without molar-incisor hypomineralization were not observed, except that the dental development of children with molar-incisor hypomineralization was more advanced than that of children without molar-incisor hypomineralization.

In another study, Kuscu et al. (2009) examined 153 children (109 from an industrial area and 44 from an island with green energy) in Istanbul, Turkey, for molar-incisor hypomineralization. Its prevalence was 9.2% in the industrial-area children and 9.1% in the island children. The study did

Table 1. Studies on the prevalence of dental anomalies in Turkey

AUTHORS	METHODS	ANOMALY	RESULTS
Sağlam and Tüzüm, 2003	1,000 patients Panoramic x-ray	Impaction	Prevalence: 11%
Yılmaz, Türkkahraman H and Sayın, 2005	5,486 patients Panoramic x-ray	Transposition	Prevalence: 0.38%
Şişman, Uysal and Gelgor, 2007	2,413 patients (1,557 female, 856 male) Panoramic x-ray Dental cast	Hypodontia exclusive of third molars	Prevalence: 7.54% (8.09% female, 6.54% male)
Altuğ-Ataç and Erdem, 2007	3,043 patients (1,658 female, 1,385 male) Panoramic x-ray	Shape anomalies: fusion, gemination, microdontia (peg-shaped maxillary and mandibular lateral incisors), and macrodontia Number anomalies: oligodontia, hypodontia (congenitally missing maxillary lateral incisors, mandibular incisors and canines, maxillary and mandibular premolars), and hyperdontia (supernumerary incisors and premolars) Structural anomalies: amelogenesis imperfecta	Prevalence Fusion: 0.23% Gemination: 0.07% Macrodontia: 0.03% Microdontia: 1.58% Hypodontia: 2.63% Hyperdontia: 0.36% Oligodontia: 0.13% Amelogenesis imperfecta: 0.43%

AUTHORS	METHODS	ANOMALY	RESULTS
Gündüz et al., 2008	23,000 patients (12,667 female, 10,333 male) Periapical x-ray Occlusal x-ray	Mesiodens	Prevalence: 0.3%
Kırzıoğlu et al., 2009	2,477 patients Radiographic examination	Dens invaginatus	Prevalence: 12%
Esenlik et al., 2009	2,599 patients (1,,360 female, 1,239 male) Panoramic x-ray Dental examination	Supernumerary	Prevalence: 2.7% Mesiodens: 51.2%
Uslu et al., 2009	900 patients (548 female, 352 male) panoramic and periapical radiographs, dental casts, intraoral photographs, and dental histories	Agenesis Dens evaginatus Dens invaginatus Impaction Supernumerary teeth Taurodontism Pulp stone Microdontia Dilaceration	Prevalence: Agenesis: 21.6% Dens evaginatus: 6.2% Dens invaginatus: 5.0% Impaction: 2.9% Supernumerary: 0.3% Taurodontism: 1.0% Pulp stone: 4.2% Microdontia: 0.7% Dilaceration: 3.2%

AUTHORS	METHODS	ANOMALY	RESULTS
		Enamel hypoplasia Short or blunt roots Ectopic eruption	Enamel hypoplasia: 0.4% Short or blunt roots: 1.2% Ectopic eruption: 0.6%
Gülsahi et al., 2009	519 patients Periapical x-ray	Pulp stone	Prevalence: 12%
Ezirganlı et al., 2010	Retrospective study 7,753 patients (4,573 female, 3,180 male)	Congenitally missing second premolars	70 in 52 cases (13 males and 39 females) The prevalence of congenitally missing second premolars was 3X higher in females than in males and 4X higher in the mandible than in the maxilla
Çelikoğlu et al., 2010 (a)	6,983 patients (4,092 female, 2,891 male) Panoramic x-ray	Transposition	Prevalence: 0.27
Miloğlu et al., 2010	2,124 patients Periapical x-ray	Dilaceration	Prevalence: 4.3%
Çakıcı et al., 2010	1,012 patients Panoramic x-ray Periapical x-ray	Dens invaginatus	Prevalence: 1.3%

AUTHORS	METHODS	ANOMALY	RESULTS
Çelikoğlu et al., 2010 (b)	3,491 patients (2,146 female, 1,345 male) Panoramic x-ray Periapical x-ray	Supernumerary	Prevalence: 1.2 % Mesiodens: 31.3% Premolar: 25% Lateral: 22.9% Distomolar: 14.5% Paramolar: 4.2% Canine: 2.1%
Çelikoğlu et al., 2010	3,341 patients (2,040 female, 1,301 male) Panoramic x-ray Lateral cephalometry	Hypodontia Oligodontia	Prevalence: 4.6% Hypodontia: 4.3% Oligodontia: 0.3%
Aktan et al., 2010	100,577 patients Panoramic x-ray Demographic data (age and gender)	Hypodontia Oligodontia	Hypodontia: 3.12% Oligodontia: 0.07%
Topkara et al., 2011	2,761 patients (1,677 female, 1,084 male) Panoramic x-ray	Hypodontia	Prevalence: 6.77%
Kazancı et al., 2011a	3,351 patients Panoramic x-ray Dental examination	Mesiodens	Prevalence: 0.3%

AUTHORS	METHODS	ANOMALY	RESULTS
Şekerci et al., 2011 (a)	4,619 patients Panoramic x-ray Intraoral photo (primary teeth)	Double teeth: Fusion Gemination	Prevalence: 0.38%
Şekerci et al., 2011 (b)	8,229 patients Panoramic x-ray (permanent teeth)	Fusion Gemination	Double teeth: 0.29% Fusion: 0.17% Gemination: 0.14%
Kaya et al., 2011	8,400 patients Panoramic x-ray	Supernumerary premolar	Prevalence: 0.24%
Kazancı et al., 2011b	3,165 patients (1,940 female, 1,225 male) Panoramic x-ray	Tooth form, number, position, structural abnormalities	Prevalence:15.05% Fusion: 0.03% Gemination: 0.03% Peg-shaped teeth: 2.15% Macrodontia: 0.41% Hypodontia: 4.30% Oligodontia: 0.25% Hyperdontia: 1.30% Transposition: 0.25% Transmigrant teeth: 0.16% Ectopic eruption: 1.52% Impacted teeth: 4.55% Inversion: 0.06% Amelogenesis imperfecta: 0.41%

AUTHORS	METHODS	ANOMALY	RESULTS
Şener, Bozdağ and Ünlü, 2011	1,100 patients Clinical and radiographic examination	Hypodontia Supernumerary Microdontia Taurodontism Dilaceration Fusion Gemination Talon cusps Dens invaginatus Amelogenesis imperfecta	Prevalence: Hypodontia: 1.09% Supernumerary: 0.07% Microdontia: 0.16% Taurodontism: 0.02% Dilaceration: 0.02% Fusion: 0.002% Gemination: 0.01% Talon cusps: 0.15% Dens invaginatus: 0.04% Amelogenesis imperfecta: 0.1%
Bayram et al., 2011	250 patients Panoramic x-ray	Hypodontia Supernumerary Talon cusps Gemination Macrodontia Microdontia Taurodontism Dilaceration	Prevalence: Hypodontia: 4.4% Supernumerary: 0.8% Talon cusps: 4% Fusion-Gemination: 0.4% Macrodontia: 7.6% Microdontia: 0.4% Taurodontism: 9.6% Dilaceration: 2%
Topçuoğlu et al., 2011	490 patients Panoramic x-ray	Taurodontism	Prevalence: 4.2%
Öztaş et al., 2011	5,200 patients Panoramic x-ray	Supernumerary	Prevalence: 1.6%

AUTHORS	METHODS	ANOMALY	RESULTS
Kara et al., 2012	104,902 patients Panoramic x-ray	Supernumerary molar	Prevalence: 0.33%
Cantekin et al., 2012	1,291 patients (678 male, 613 female) Panoramic x-ray	Hypodontia exclusive of third molars	Prevalence: 6.2%
Çolak et al., 2012	6,912 patients (2,324 female ve 4,243 male) Panoramic x-ray	Dens invaginatus	Prevalence: 0.008%
Çelikoğlu et al., 2012	3,872 patients Panoramic x-ray Periapical x-ray	Maxillary lateral incisor agenesis	Prevalence: 2.4%
Kapdan et al., 2012	1,149 patients (554 female vs. 595 male) Clinical examination (primary teeth)	Tooth size, morphology, and number	Prevalence: 2% Hypodontia: 0.2% Supernumerary: 0.3% Microdontia: 0.3% Double teeth: 1.3%
Arfat et al., 2012	2,597 patients Clinical examination	Talon cusps	Prevalence: 1.2%
Uzuner et al., 2013	2,530 patients (1,382 female, 1,148 male) Panoramic x-ray Dental examination	Hypodontia	Prevalence: 5%

AUTHORS	METHODS	ANOMALY	RESULTS
Gündüz et al., 2013	5,355 patients Panoramic x-ray Periapical x-ray	Dens invaginatus	Prevalence: 2.5%
Arıkan et al., 2013	7,551 patients Clinical and radiographic examination	Supernumerary	Prevalence: 0.98% Mesiodens: 36.9%
Çolak et al., 2013	11,256 patients Panoramic x-ray	Mesiodens	Prevalence: 0.13%
Aslan and Akarslan, 2013	378 patients (240 female, 138 male) Panoramic x-ray	Hypodontia Supernumerary	Prevalence: Hypodontia: 55.9% maxillary, 44.1% mandibular teeth Supernumerary: 72.4% maxillary, 27.6% mandibular teeth
Karadaş et al., 2014	2,722 patients (1,532 female, 1,190 male) Panoramic x-ray	Hypodontia Hyperdontia Oligodontia	Prevalence: 4.84% Hypodontia: 3.67% Hyperdontia: 0.96% Oligodontia: 0.21%
Gökkaya, Motro and Kargül, 2015	1,236 patients (729 male, 507 female) Panoramic x-ray	Hypodontia	Prevalence: 7%

AUTHORS	METHODS	ANOMALY	RESULTS
Aren et al., 2015	2,025 patients (1,140 female, 885 male) Panoramic x-ray	Hypodontia Hyperdontia Microdontia Taurodontism Root anomalies	Prevalence: 4.74% Hypodontia: 1.77% Hyperdontia: 0.79% Microdontia: 0.54% Taurodontism : 1.18% Root anomalies: 0.44%
Bekiroğlu et al., 2015	1,056 patients (536 male, 520 female) Panoramic x-ray	Mesiodens Supernumerary Fusion Impacted teeth	Prevalence: Mesiodens: 3.50% Supernumerary: 0.85% Fusion: 1.89% Impacted teeth 1.52%
Ağlarcı et al., 2016	3,600 patients (2,200 male, 1,400 female) Panoramic x-ray	Hypodontia Oligodontia Hyperdontia Macrodontia Taurodontism Dilaceration	Prevalence: Hypodontia: 4.3% Oligodontia: 0.2% Hyperdontia: 0.7% Macrodontia: 0.03% Taurodontism: 0.08% Dilaceration: 0.4%
Almaz et al., 2017	9,173 patients Clinical and Radiographic examination	Hypodontia Supernumerary Fusion Gemination Taurodontism	Prevalence: Hypodontia: 0.52% Supernumerary: 0.27% Fusion: 0.09% Gemination: 0.06% Taurodontism: 0.02%

AUTHORS	METHODS	ANOMALY	RESULTS
		Dilaceration Macrodontia Microdontia Dens invaginatus Dentinogenesis imperfecta Amelogenesis imperfecta	Dilaceration: 0.02% Macrodontia: 0.02% Microdontia: 0.01% Dens invaginatus: 0.03% Dentinogenesis imperfecta: 0.02% Amelogeneis imperfecta: 0.05%
Güven et al., 2017	14,400 patients Clinical examination	Talon cusps	Prevalence: 0.34%
Bilge et al., 2017	1,200 patients (662 female, 538 male) panoramic radiographs	Number (including hypodontia, oligodontia and hyperdontia) Size (including microdontia and macrodontia) Structure (including amelogenesis imperfecta, dentinogenesis imperfecta and dentin dysplasia) Position (including transposition,	Number: 17% Hypodontia: 13.8% Size: 8.2% Structure: 0.2% Amelogenesis imperfecta: 0.08% Position: 60.8% Impaction: 5.5%

		ectopia, displacement, impaction and inversion) Shape (including fusion-gemination, dilaceration and taurodontism)	Shape: 27.8% Fusion-gemination: 0.08% Dilaceration: 16.3% Taurodontism: 11%

Table 2. Case Reports on Dental Anomalies in Turkey

Amelogenesis imperfecta		
Authors	**Patients**	**History and Findings**
Yavuz et al., 2002	Age = 14 yrs Female	**Case** Complained of hypoplastic teeth. Amelogenesis imperfecta was diagnosed by clinical and radiographic examinations. Her brother had similar clinical findings.
Ayna et al., 2008	**Case (1)** Age = 16 yrs Male **Case (2)** Case 1's elder sister	**Case (1)** Enamel loss on teeth in the mouth. No contact points between the teeth. **Case (2)** The teeth present in the mouth had thin enamel and no contact points between them.
Ağaçkıran et al., 2011	Age = 12 yrs Male	**Case** He was self-conscious and unhappy about the appearance of his teeth. Clinical examination revealed that there was tissue loss of all teeth. The enamel layer was very thin and brown (pigmented), no cusps on the occlusal surfaces of the molars.

Authors	Patients	History and Findings
		Molars were severely affected. Enamel pits (pigmented stains deep) were present on the anterior teeth. The clinical appearance of cervical and approximal enamel seemed to be normal.
Halıcıoğlu et al., 2011	Age = 16 yrs Male	**Case** There was no contra-indiction for dental therapy. However, the patient was not pleased with the appearance of his teeth. Patient had Class I molar relationship, mild skeletal Class III relationship, moderate spacing between the maxillary incisors and mild crowding in premolar and canine areas. Upper left canine tooth could not erupt into the arch due to crowding. Stainless steel crowns were present on all first molars.
Kanat et al., 2013	Age = 17 yrs Male	**Case** Clinical and radiographic evaluations showed amelogenesis imperfecta. Treatment was by prosthetic restorations.
Kirmali, Sekmen and Battal, 2014	Age = 22 yrs Male	**Case** The patient was concerned about his appearance and poor masticatory efficiency due to destruction of crowns. No abnormalities were found in his medical history. The family history revealed that his parents and brothers were not affected by amelogenesis imperfecta.
Batak, 2015	Age = 17 yrs Female	**Case** Extra-oral examination showed an increase in muscle activity due to reduced vertical dimension. Intra-oral examination showed that some of his teeth were lost due to failed canal treatment.

Authors	Patients	History and Findings
Tuncer et al., 2015	**Case (1)** Age = 18 yrs Female **Case (2)** Age = 28 yrs Female	**Case (1)** There was no systemic disease. Dark brown stains were observed on the enamel which appeared opaque. The enamel was soft. **Case (2)** There was no systemic disease. The mandibular and maxillary anterior teeth were yellow-brown in color and notched. The enamel surfaces were pitted. There was spacing of the lower anterior segement.
Koruyucu et al., 2015	**Case (1)** Age = 23 yrs Male **Case (2)** Age = 14 yrs Female **Case (3)** Age = 19 yrs Male	**Cases 1, 2, 3** Hypoplastic type of amelogenesis imperfecta was diagnosed in three siblings. On clinical examination, they all had delayed eruption in permanent teeth, opaqueness of the enamel on the primary and permanent teeth, conical and cylindrical structure of primary teeth crowns, no contact points between teeth, decreased vertical height and lower face due to the tooth wearing, and Class 3 malocclusion.
Dönmez and Unlu, 2015	**Case (1)** Age = 25 yrs Male	**Case (1)** On clinical examination, the mandibular left first molar tooth had been extracted, the mandibular and maxillary anterior teeth were notched with yellow-brown discoloration, and the surfaces were pitched. The general and dental health of the family were both normal. On radiologic examination, congenital defects were found in the maxillary lateral incisor and the right maxillary primary molar.

Authors	Patients	History and Findings
	Case (2) Age = 13 yrs Female	**Case (2)** On clinical examination, there was attrition of the maxillary anterior teeth with brown and black dentine stains. The teeth were notched. In addition, the maxillary canine was displaced labially, and the patient was open-bite. The tubercles of the maxillary molar and the mandibular anterior teeth were notched with yellow-brown discoloration. Radiographs showed that the mandibular right first molar was extracted, there was external resorption at the root of the mandibular right second premolar, and the left second premolar was congenitally missing.
İnce et al., 2016	Age = 23 yrs Female	**Case** Intra-oral examination revealed enamel defects of the teeth and exposed dentine surfaces.
Sadık et al., 2016	Age =20 yrs Male	**Case** There was no systemic disease or drugs that he used constantly. No abnormality was detected on oral examination. There was no soft tissue pathology on the intra-oral examination. The patient's periodontal health and oral hygiene were good. All the teeth in the mouth had yellow-brown stains of the enamel.
Ozener, Gemalmaz and Kuru, 2017	Age = 27 yrs Female	**Case** Intra-oral examination of the systemic-healthy patient revealed that all teeth were present with an opaque appearance and diffuse yellow-brown stains of the thin enamel layer.

Dentin dysplasia		
Authors	**Patient**	**History and Findings**
Erdem et al., 2012	Age = 10 yrs Female	**Case** The patient presented with the characteristic features of dentin dysplasia types I and II. All teeth were involved with amorphous type crown and no root. Short roots or malformed roots were associated with severe mobility. Dysplasia type III could be a new diagnostic entity.
Dentinogenesis imperfecta		
Authors	**Patients**	**History and Findings**
Bayındır, Bayındır and Seven, 2005	Age = 22 yrs Male	**Case** The teeth had a grey or brown, opalescent appearance on the enamel attrition and, mandibular fracture. Radiographically, the crowns were bulbous and the roots were short and blunt. His father, sister, and brother had similar findings and had a history of spontaneous bone fractures.
Güven et al., 2016	Age = 20 yrs Male	**Case** His brother also had dentinogenesis imperfecta. On extra-oral examination, the tip of the patient's lower jaw was prominent. Intra-oral examination showed the loss of many teeth, and there was no enamel on most of the remaining teeth, which were discolored, exposing soft dentine tissue with calcification disorder. Despite the marked tooth loss, the pulp chambers were not exposed. Radiographically, he had impacted teeth and teeth with short roots and large pulp chambers.

Dilaceration		
Authors	**Patient**	**History and Findings**
Sönmez and Sönmez, 2008	Age = 10 yrs Male	**Case** An impacted dilacerated maxillary right central incisor tooth with no apparent history of trauma.
Hyperdontia		
Authors	**Patients**	**History and Findings**
Sumer, Hosgör and Sumer, 2006	**Case (1)** Age = 19 yrs Female	**Case (1)** The patient presented with a complaint of tenderness to cold shards in the mandibular right molar tooth. On the panoramic radiograph, an implanted paramolar tooth was observed just above the third molar tooth embedded in the right upper canine.
	Case (2) Age = 23 yrs Female	**Case (2)** The patient presented with complaints of tenderness and pain in the left and right mandibular molar regions. On the panoramic radiograph, a distomolar tooth distal to the third molar tooth was detected.
	Case (3) Age = 47 yrs Male	**Case (3)** Clinical examination of the patient with bleeding of the gingiva and breakdown of the crown of the maxillary canine. Radiographic examination revealed an impacted left third molar. A paramolar was also present above the impacted molar.
	Case (4) Age = 23 yrs Female	**Case (4)** The patient was admitted to the hospital due to the presence of a tooth anterior to the maxillary right second and third molars. On clinical examination, a paramolar

Authors	Patients	History and Findings
		tooth was found in the buccal region between the maxillary right second and third molars. A paramolar was embedded between the molars.
	Case (5) Age = 25 yrs Male **Case (6)** Age = 31 yrs Female	**Case (5)** The patient's routine panoramic radiographic examination revealed a distomolar embedded close to the upper left canine. **Case (6)** A radiologic examination of a referred patient with caries on the maxillary left third molar revealed a distomolar embedded close to the maxillary left canine.
Sencimen et al., 2006	**Case (1)** Age = 8 yrs Male **Case (2)** Age = 11 yrs Male **Case (3)** Age = 8 yrs Male	**Case (1)** Patient complained of the assymetrical shape of maxillary incisors. The history showed no systemic disease and no family history of any pathology. On clinical examination, the maxillary left central incisor was in the normal position, and a conical tooth was observed in the place of the maxillary right central incisor. **Case (2)** No systemic disease. There are no pathologic findings in her family history. Clinical examination revealed a fistula in the middle of the upper jaw. On periapical and panoramic radiographs, inverted supernumerary teeth were observed between the maxillary central incisors. **Case (3)** No systemic disease. Two supernumerary teeth were observed on the periapical and panoramic radiographs. One of them was located between the maxillary central incisors and the other was located in the apex region of the right maxillary central incisor.

Authors	Patients	History and Findings
Catalbas, Celebi and Gelgor, 2010	Age = 18 yrs Male	**Case** The patient had no systemic or familial complaints. His general health was normal, and no one in the family had multiple teeth. On clinical examination, a premolar was observed on the left side of the lower canine in the lingual sulcus, and a space was observed between the premolars. The molar had a class I relationship. On panoramic, periapical and occlusal radiographs, two supernumerary premolars were detected on the left and right of the mandible respectively.
Erdem et al., 2011	**Case (1)** Age = 30 yrs Female **Case (2)** Age = 40 yrs Female **Case (3)** Age = 26 yrs Male **Case (4)** Age = 16 yrs Male	**Case (1)** No systemic disease was detected. No anomaly on extra-oral examination. On the intra-oral and radiographic examinations, supernumerary teeth were located on the palate of the maxillary right second and third molars. **Case (2)** No systemic disease was detected. No abnormalities were observed in the extra-oral and intra-oral examinations. On the panoramic and periapical radiographs, a supernumerary tooth was observed in the mandible. **Case (3)** No systemic disease detected. On clinical examination, a diagnosis of pericoronitis was made for one of the teeth. **Case (4)** No systemic disease was detected. No anomaly was seen on extra-oral and intra-oral examination. The panoramic radiograph revealed supernumerary teeth in the mandibular premolar region bilaterally.

Hypodontia		
Authors	**Patients**	**History and Findings**
Kılınç et al., 2014	**Case (1)** Age = 17 yrs Female	**Case (1)** The panoramic radiograph showed that the maxillary lateral incisors were missing. There was hypodontia observed in the youngest child in the family. No missing teeth in the babies in the family. Mother and grandparents had missing maxillary left lateral teeth, while a sibling had a maxillary left lateral tooth missing.
	Case (2) Ages = 7 and 12 yrs Female	**Case (2)** On oral examination, both sisters had maxillary left and right lateral incisors congenitally missing. The lateral upper jaw defect was detected in the prenatal anamnesis of the child.
	Case (3) Age = 13 yrs Female Age = 8 yrs Male	**Case (3)** She had the mandibular right and left second premolars, the mandibular second molar and all third molars missing. On intra-oral examination of the brother, the mandibular right and left first primary molars had dental caries. The panoramic radiograph showed congenitally missing second primary molars. In the family history, the mother had congenitally missing mandibular second primary molars.
	Case (4) Age = 5 yrs Female	**Case (4)** The mandibular left lateral primary tooth was congenitally missing. The panoramic film showed a congenitally missing mandibular left permanent lateral tooth. The intra-oral examination of the mother showed that the maxillary right and left lateral teeth were missing.

Authors	Patients	History and Findings
Peker et al., 2015	Age = 6 yrs Male	**Case** The patient came to clinic because of esthetic and chewing impairment due to multiple missing teeth. He had no systemic disease. There was no consanguineous marriage in the family, and no other family member had any missing teeth. There was no history of trauma and no syndrome was found in the genetic evaluation. Extra-oral examination revealed facial asymmetry and a slight decrease in facial height with a flat facial profile. Intra-oral and radiographic examinations revealed that the teeth were normal in size, shape and color. Cephalometric examinations showed that the maxillary vertical height was high and Class III skeletal malocclusion was present.
Avcı et al., 2016	**Case (1)** Age = 6 yrs Male	**Case (1)** He complained of caries in the primary teeth and a missing primary left canine. He had no systemic disease and there was no evidence to suggest that he had a syndrome. The maxillary left canine was not present in the mouth, and there was a gap between the maxillary right lateral and first primary molar. The maxillary second molar had dentine caries. The periapical radiograph showed alveolar resorption around the maxillary left permanent canine. Panoramic radiographs showed that the development of the maxillary left permanent canine tooth germ was more advanced than that of the maxillary right permanent canine tooth germ. No other missing teeth were found, and the dental development appeared normal for the age of the patient.

Authors	Patients	History and Findings
	Case (2) Age = 4 yrs Male	**Case (2)** He had no systemic disease or syndromes. On the oral examination, the mandibular left primary second molar had caries, and the mandibular left primary canine was clinically missing. No history of tooth extraction and trauma. No other missing teeth. No missing tooth in the mouth of his twin brother.
Microdontia		
Authors	**Patients**	**History and Findings**
Kucukesmen and Kucukesmen, 2005	**Case (1)** Age = 5 yrs Male **Case (2)** Age = 10 yrs Female **Case (3)** Age = 11 yrs Male	**Case (1)** The maxillary left primary central incisor was conical; the anomalous tooth resembled a nail. **Case (2)** The maxillary left lateral tooth was conically shaped. **Case (3)** The maxillary left and right permanent lateral incisor were conically shaped.
Baygın, Tuzuner and Tanriver, 2011	**Case (1)** Age = 11 yrs Male	**Case (1)** At age three years, he had treatment for non-Hogkin lymphoma using mantle-field radiotherapy. Dental caries were seen on all the primary second molars and permanent first molars. The maxillary right primary first molar was mobile. All primary, the second molars were microdonts.

Authors	Patients	History and Findings
	Case (2) Age = 13 yrs Male	**Case (2)** At the age of four years, he had Burkitt lymphoma treated by mantle-field radiotherapy. The medical history revealed that the patient was in excellent general condition. He had mobility in the maxillary left primary second molar and microdontia of all primary second molars.
Tunc et al., 2018	Age = 13 yrs Female	**Case** The patient was referred to a dental clinic complaining about caries in anterior teeth. Intra-oral examination revealed gross carious lesions and microdontia of the premolar and second permanent molar.
Oligodontia		
Authors	**Patients**	**History and Findings**
Sagesen, Yamalik and Suca, 2000	Age = 20 yrs Female	**Case** The patient had difficulty chewing due to the absence of many posterior teeth. She had four permanent and 13 primary teeth that were malformed.
Celik and Gungor, 2002	**Case (1)** Age = 19 yrs Female **Case (2)** Age = 16 yrs Female	**Case (1)** Had four permanent and 18 primary teeth in the oral cavity. Four of the 18 primary teeth were malformed. The other primary and permanent teeth had normal anatomic contours. **Case (2)** The patient had only 20 permanent teeth with normal anatomical contours.
Akkaya et al., 2006	Age = 22 yrs Female	**Case** The patient was healthy, but had 12 permanent teeth missing. There was a family history of hypodontia. Class III malocclusion, open bite, and diastemia in the

Authors	Patients	History and Findings
		anterior region were observed. Mandibular primary teeth and the maxillary right primary molar were present. The maxillary first premolar teeth were rotated and maxillary and mandibular molars had caries. Radiographic evaluation showed that the patient's maxillary laterals, maxillary second premolars, mandibular central and lateral incisors, mandibular right cannula, and mandibular second premolars were congenitally missing.
Gündüz and Yenisey, 2007	Age = 17 yrs Female	**Case** Panoramic examination revealed that 13 permanent teeth were absent in the maxilla and mandible including the third molars.
Sisman, Ertas and Dundar, 2007	**Case (1)** Age = 19 yrs Female **Case (2)** Age = 15 yrs Male	**Case (1)** After genetic consultation, the lesion was found not to be associated with any syndromes or systemic abnormalities. Only 16 teeth were present in the mouth and the teeth were microdonts. **Case (2)** After genetic consultation, the lesion was not associated with any syndromes or systemic abnormalities. On intra-oral examination, only five permanent teeth were present. The panoramic radiograph showed 23 missing permanent teeth. Third molars were present.
Ekren, Benlidayi and Karan, 2010	Age = 17 yrs Female	**Case** The general health and appearance of the patient were normal. There was no systemic disease or history of tooth extraction. Intra-oral examination revealed that 18 permanent teeth were missing. The third molars were present. There were no caries on the permanent teeth. There were retained primary teeth. The patient did not have any periodontal problem.

Authors	Patients	History and Findings
Kılınç and Sevinç, 2012	**Case (1)** Age = 9 yrs Female **Case (2)** Age = 9 yrs Male	**Case (1)** Seven permanent teeth were missing and there were no associated anomalies. She was the only child of the family. No family history of congenital teeth missing. **Case (2)** Six premolars were missing and there were no associated anomalies. He was the only child of his family and there was no family history of congenitally missing teeth.
Akgün et al., 2015	Age = 14 yrs Female	**Case** Clinical and radiologic examination revealed that only the maxillary permanent incisors, right and left first and second molars, and the mandibular left first molar were present. Extra-oral examination showed that the patient did not have a developmental problem. Ectodermal dysplasia was absent. There was no systemic or congenital disease in his history. It was unknown whether the patient had a genetic disease or not because a test could not be conducted. The mother had not received radiotherapy during the pregnancy and did not take any medication. There was no history of similar tooth defects in the family.
Derindağ et al., 2016	**Case (1)** Age = 8 yrs Female **Case (2)** Age = 10 yrs Male	**Case (1)** No systemic disease. Panoramic radiograph showed 14 missing teeth. No other anomalies were detected. **Case (2)** No systemic disease. Panoramic radiograph showed eight missing teeth. No other anomalies were detected.

Transposition		
Authors	**Patients**	**History and Findings**
Türk et al., 2001	**Case (1)** Age = 13 yrs Female **Case (2)** Age = 15 yrs Female	**Case (1)** The maxillary right and left canines were located between the first and second premolars. **Case (2)** In the maxilla, the left canine was buccally displaced and lay mesial of the central incisor. The root of the lateral incisor was located palatal to the canine.
Alkan and Kaya, 2015	Age = 13 yrs Female	**Case** Patient had a convex profile, an angle Class I molar relationship on the right side, a 3 mm overjet, a 1 mm overbite, and a 1 mm upper midline shift to the left. Panoramic radiograph revealed that the maxillary right first permanent molar was missing, the maxillary left primary canine was retained, and the maxillary left permanent canine was impacted. Diastema was present in the upper and lower dental arches along with a unilateral complete transposition of the maxillary left permanent lateral and canine.
Taurodontism		
Authors	**Patients**	**History and Findings**
Kosger, Konarili and Ay, 2003	Age = 21 yrs Male	**Case** Radiographic examination showed taurodontism of the maxillary left permanent first molar, the right permanent second molar, the mandibular left and right permanent second molars; root resorption and a large radiolucent lesion in the periapical region of the mandibular left permanent second molars. Teeth had a clinically normal appearance, and the patient did not have any systemic disease or genetic abnormality.

Authors	Patients	History and Findings
Ahmetoglu, Simsek and Ocak, 2013	Age = 19 yrs Gender unspecified	**Case** Hypertaurodontism of the maxillary left first molar and the mandibular right first molar was found. The individual was healthy and without any associated syndrome or anomaly.

not find a relationship between environmental factors and molar-incisor hypomineralization. Longitudinal studies with larger sample sizes are needed to determine whether environmental factors play a role in molar-incisor hypomineralization development in Turkey.

Gaps and Recommendations

Dental anomalies are the most comprehensively investigated dental topic in Turkey. However, studies on eruption times, delayed tooth eruption anomalies, and hard dental-tissue anomalies are lacking. Further research in these areas is needed. Also, more resources are needed to fully assess chronological age and dental age in the primary teeth, and genetic studies are required to determine the inheritance patterns and genes involved in dental disease in the Turkish population.

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UZBEKISTAN

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Background Information on Uzbekistan

The Republic of Uzbekistan is in central Asia where it shares borders with Kazakhstan in the north and northeast, Turkmenistan in the southwest, Afghanistan in the south, Tajikistan in the southeast, and Kirghizia in the northeast. About four-fifths of the territory is desert plains. The eastern and southeastern regions of the country have mountains and foothills – the Tien Shan and the Hissar Range. The climate of Uzbekistan is continental, with long, hot and dry summers and cold, snowless winters.

The country is multi-ethnic: 80% of the population are Uzbeks, and about 5.5% are Russians. Other ethnic groups are Tajiks (5%), Kazakhs (3%), Karakalpaks (2.5%), Tatars (1.5%) and Kirghizs (1%). Almost 60% of the population are rural residents, and 90% of the rural residents are central Asians.

The government of the Republic of Uzbekistan pays close attention to education, with the aim of supporting a strong and healthy young generation. The country has developed policies and programs with the goals of education and health promotion of the current and future generations. One goal is the protection of children's health in regions that have unfavorable ecological situations, such as the death of the Aral Sea and the dehydration and desertification of lands in its basin. Salt fields

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have appeared on the bottom of the former sea, and wind carries sand to a radius of more than 500 km, polluting the air and salting the fertile land. The disappearance of the sea has caused the aridization of the region, with the resulting excessive heat; the air temperature has increased by 1-1.5°C in this region, and the number of days with a temperature of 40°C has increased to 10-12. In some places, the temperature is as high as 49°C. The threat to the environment, flora and fauna, health and the gene pool of the population of the region is higher in the Aral Sea territory.

Figure 1. Map of the Republic of Uzbekistan

The change in climate has had deleterious effects on health. One effect is an increase in the prevalence of clefts of the upper lip and palate in large regions and in Tashkent city. This effect has occurred despite a decline in fertility. The average incidence rate for clefts is one case per 745 live births. The highest rates were registered in the Aral region, with one case in 540 live births (Amanullayev, 2005). The combination of unfavorable socio-hygienic, medico-biological, socio-psychological and material living conditions, as well as environmental factors, increases the risk of babies being born with a congenital cleft of the upper lip and palate.

Timing and sequence of emergence of primary and permanent dentitions

There are no data on the timing and sequence of emergence of the primary and permanent dentition. However, there are data on the timing of emergence of the first permanent molars from the study of Mirsalixova (2004), conducted in Tashkent city. The first permanent molars began to erupt at 4.5 years. The mineralization of teeth was completed in stages: first the tubercles, then the equator, then the pouch and, lastly, the fissures of the teeth. Tooth emergence occurs on average at the age of 5-6 years of age. The period of mineralization of hard tissues of teeth lasts for 1.5-3 years.

Developmental Dental Hard-tissue Anomalies

Children living in areas with environmental pollution are more likely to suffer from dental diseases – fluorosis (16.2%), dental hypoplasia (11.9%) and dentoalveolar anomalies (37.8%) –than children living in the Jarkurgan and Baysun areas, where the environmental pollution is significantly less. The prevalence of dental anomalies in the Dzharkurgan area, where the use of pesticides is high, was reported as 8.9% for dental hypoplasia and 25% for dentoalveolar anomalies. In the city of Chirchik, where environmental pollution is high, the reported prevalence of enamel hypoplasia was 9.7% and that of dentoalveolar anomalies was 24.6%. The prevalence of fluorosis in Chirchik and Dzharkurgan was 8% in the primary dentition and 8.2% in the permanent dentition in both places (Zhumatov, 1994).

The high prevalence of developmental dental hard-tissue anomalies has been attributed to the intensive use of chemicals for agricultural purposes, which has deleterious effects on immunity, such as disruptions in the activity of hydrolases and dehydrogenases in immunocompetent cells. In regions where there is intensive use of pesticides for agriculture, the developmental milestones of the children are slower, with a significantly high proportion of children having neuropsychiatric development and chronic diseases (Zhumatov, 1994).

Gaps and Recommendations

Much research is needed in the Republic of Uzbekistan to determine the timing and sequence of dental emergence, and to determine the epidemiological profile of developmental dental anomalies in the populations. These data are important for several reasons, including for forensic pathology purposes; with continuing evolution and globalization, these data may be needed for the identification of citizens of the Republic of Uzbekistan.

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VENEZUELA

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Background Information on Venezuela

Venezuela is in northern South America. It has a tropical climate and a diverse landscape, including rainforests, deserts, beaches, and the Andean Mountains (Figures 1 and 2). It is multi-ethnic, with people of diverse socioeconomic status (Barreto et al., 2012). The indigenous population is comprised of various Indian tribes, though few native tribes remain today. Most of the population is a mixture of races of Spanish descent and people with African, American, and Indian origins. About 90% of the population self-recognize as Creole, 4% as African descendants, and 6% as Indian, including tribes such as Wayúu, Pemón, Piaroa, and others (Morón, Borjas and Córdova, 2008).

Poverty and malnutrition in Venezuela have worsened in the last few years. About ten years ago, nearly 20% of families lived in poverty, and 10% lived in extreme poverty (Instituto Nacional de Estadísticas República Bolivariana de Venezuela, 2011; UNICEF, 2016). In 2009, the prevalence of chronic malnutrition in children under 5 years of age was 9.5%, and the prevalence of acute malnitition was 3.2% (UNICEF, 2016; Fundación Bengoa, 2016). More recent data indicate that the percentage of Venezuelans who live in poverty and are malnourished is significantly higher (España, 2016; Landaeta-Jiménez, et al., 2016).

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Figure 1. Political map of Venezuela. Obtained from:
http://mapadevenezuela.com.ve/mapa-de-venezuela-por-estados/

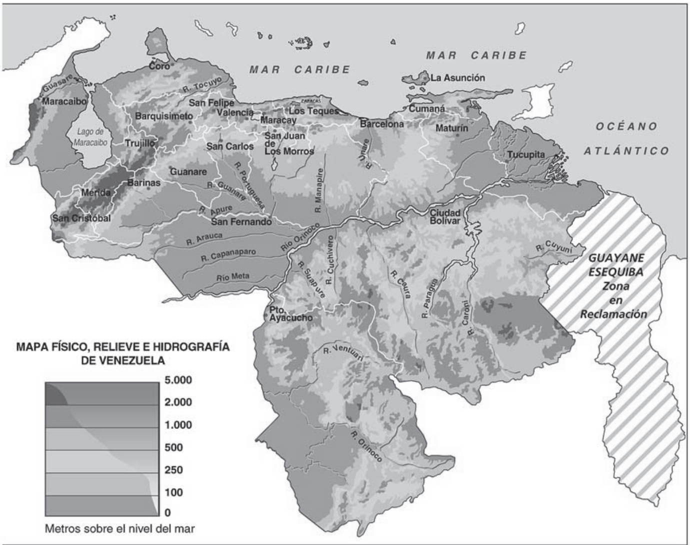

Figure 2. Geographic map of Venezuela. Obtained from:
http://mapadevenezuela.com.ve/mapa-de-venezuela-relieve/

National salt fluoridation programs have been carried out in Venezuela since the 1990s. Water fluoridation, though, has not been deemed a suitable approach, since many communities lack access to running tap water. Dental fluorosis has been linked to high well-water fluoride concentrations in many communities (Montero et al., 2007).

Timing and Sequence of Emergence of Primary and Permanent Dentitions

The FUNDACREDESA (1995) study is the largest study of tooth emergence profiles in Venezuela. The investigators examined 53,537 children, aged 0 to 20, and determined that the most prevalent tooth emergence sequence was 41, 31, 36, 46, 16, 26, 11, 21, 42, 32, 22, 12, 24, 33, 34, 44, 14, 43, 23, 13, 45, 35, 25, 15, 47, 37, 27, 17. Significant differences in tooth emergence timing were not observed between the genders or between various socioeconomic groups. The mandibular central incisors erupted before the first permanent molars.

Morón et al. (2006) compared the sequence and timing of tooth emergence in Wayúu (an indigenous tribe of the northwestern coasts of Venezuela and Colombia) and Creole (multi-racial Venezuelan) children. The two groups had a similar emergence sequence, but emergence was earlier for the Wayúu children. The authors hypothesized that these differences were due to ethnicity as well as cultural and dietary patterns.

Zapata (2013) studied tooth eruption in Venezuelan children by comparing panoramic radiographs with the Schour and Massler chart. The tooth eruption sequence in the radiographs was similar to that proposed in the charts. Compared with the Schour and Massler chart, the radiographs revealed statistically significant mandibular central incisor eruption and delayed eruption of first and second maxilary premolars. Also, statistically significant delays in root formation were observed for the mandibular lateral incisor, the maxillary first and second premolars and second molar, and the mandibular second premolar.

Dental age is a clinically important somatic maturation indicator for treatment planning in growing patients. Medina and Blanco (2013) determined the accuracy of the dental age method proposed by Nolla in a group of 238 healthy Venezuelan children from the Caracas Metropolitan area. The subjects were stratified by age and gender. The correlation coefficient between chronological age and dental age was 0.92 ($p = 0.01$).

Dental maturation was dalayed in boys compared to girls, and significant differences were observed with the canines and the maxillary first premolar. The Nolla method underestimated the chronologic age: for the overall study population the mean years of underestimation were -0.88 ± 0.94 (p ≤0.01). The underestimation was larger for females (-1.04 ± 0.93 years) than for males (-0.72 ± 0.94 years). The authors concluded that the Nolla method can accurately identify the stage of dental formation by age group in Venezuelan children, but it lacks accuracy for determining dental age (Medina, 2012a).

Medina and Blanco (2014) found that the Willems method was more accurate than the Demirjian method for the estimation of dental age in a group of 238 healthy 5-13-year-old Venezuelan children. With the Demirjian method, the mean difference between dental age and chronologic age was 0.62 ± 0.93 years, and this was statistically significant. The mean overestimation was less for females (0.56 ± 0.96 years) than it was for males (0.67 ± 0.93 years). With the Willems method, the mean difference between dental age and chronologic age was 0.15 ± 0.97 years, but this was not statistically significant. A significant difference was observed between genders: the mean overestimation was 0.01 ± 0.96 years for girls and 0.29 ± 0.96 years for boys. The overestimations reported in these studies were lower than those found by Tineo et al. (2006) – 0.9 years, and Espina de Ferreira et al. (2007) – 1.52 years, in their assessments of children who resided in the Maracaibo Lake region, where the correlation between dental and skeletal age is high. Cruz-Landeira et al. (2009) used the Demirjian method to assess children from the Andes region and reported a dental age underestimation of 0.23 years.

Although dental development is mainly influenced by genetics, it may be influenced also by systemic, or environmental, conditions. Variations in dental development among patients with dental agenesis were reported by Medina (2012b), who evaluated 1,188 panoramic radiographs of healthy patients, aged 5 to 12 years. Dental age, assessed with the Nolla method, was significantly delayed in Venezuelan children who had dental agenesis. The formation of some teeth was also delayed in children with agenesis (second molars ($p < 0.05$), maxillary lateral incisors, and second premolars). Despite the dental development delays, the timing of tooth emergence was similar for both groups, with or without agenesis (Medina, Del Pozo and Blanco de Cedres, 2016).

Developmental Hard Dental Tissue Anomalies

Agenesis/hypodontia: Dental agenesis is the most common developmental disturbance in humans. It can cause malocclusion as well as functional and esthetic problems. Timely diagnosis in pediatric patients allows for proper treatment and interdisciplinary management, which can improve outcomes (Nunn et al., 2003). In the FUNDACREDESA (1995) study, the national prevalence of clinically observed agenesis was 1.52%. Medina et al. (2012) evaluated 1,188 panoramic radiographs of 5-12-year-old patients in the Caracas region and found an agenesis prevalence of 5.6%. Third molar agenesis was not included in the evaluation. A total of 108 teeth were missing: the second mandibular premolars were most affected (35.19%), followed by the lateral maxillary incisors (31.55%). Females were affected more than males (ratio 1.44:1). Most (90.9%) patients had agenesis of one or two teeth.

Medina et al. (2012) performed another study to determine the prevalence of hypodontia in a pediatric orthodontic population in Caracas. A total of 607 radiographs from 5-11-year-old patients who were scheduled for interceptive orthodontic treatments were assessed. Patients with hypodontia affecting the third molar, and those with cleft lip, or palate, were excluded. Overall, 25 patients (4%) had hypodontia: 13 had single-tooth agenesis and 12 had multiple-tooth agenesis. Females were affected more than males (ratio 1.5:1). A total of 40 teeth were missing, including the permanent maxillary lateral incisors (40%), the mandibular second premolars (23%), the maxillary second premolars (15%), the permanent mandibular lateral incisors (15%), and the permanent mandibular second molars (8%). The maxilla was more affected (55%) than the mandible (45%). Symmetry was noted for hypodontia in the maxilla, and an inverse correlation was found between maxillary and mandibular hypodontia (Medina and Martínez, 2009).

Loaiza and Cárdenas (2001) studied 1,251 panoramic radiographs (excluding the third molars) of patients in the Carabobo State region and identified 52 (4.16%) patients with dental agenesis. Girls were affected more than boys (4.9% vs. 3.08%). Of those with agenesis, 88.4% had one or two affected teeth. The most affected teeth were the maxillary lateral incisors (56.25%), followed by the mandibular second premolars. The studies that reported the prevalence of agenesis, excluding the third molars, are presented in Table 1.

Table 1. Reported prevalence of dental agenesis assessed radiographically, excluding the third molars

Study	Number of subjects	Agenesis prevalence	Female/ Male	Most affected tooth
Loaiza and Cárdenas, 2001	1,251	4.16%	F>M	Maxillary lateral incisor
Iglesias, Manzanares and Valdivia, 2007	97	6.19%	F>M	Maxillary lateral incisor
Medina, 2012	607	4.15%	F>M	Maxillary lateral incisor
Medina et al., 2012	1,188	5.66%	F>M	Mandibular second premolar

Mendez and Contreras (2006) studied a population of 397 patients and found that the prevalence of agenesis increased when the third molars were included. In that study, the prevalence was 15%, and it was higher for girls than for boys. The most affected teeth were the third molars (67%), followed by the maxillary second premolars.

Supernumerary teeth: Supernumerary teeth can be found in any area of the maxilla or mandible. The shape can be classified as conical, tuberculate, or supplemental. Mendez and Contreras (2006) studied a population of 397 patients and reported a supernumerary tooth prevalence of 1%. The most common form was the mesiodens (75%).

Iglesias, Manzanares and Valdivia (2007) analyzed the panoramic radiographs of 97 children from Mérida and found the prevalence of supernumerary teeth was 5.15%. Medina and Martínez (2011) analyzed the panoramic radiographs of 550 healthy patients (mean age of 8.01 $\pm$ 3.05 years) and reported a prevalence of 4.55%. In that study, 25 patients (8 females and 17 males; ratio 2.1:1) had 34 supernumerary teeth. Sixteen patients had one and nine patients had two supernumeraries. The shapes of the supernumerary teeth were conical (21 teeth), tuberculate (eight teeth), and supplemental (five teeth). Most (79.4%) of the supernumerary teeth were in the maxillary anterior apical area, and most (88.2%) were not erupted.

Jiménez de Sanabria et al. (2012) examined the orthodontic records (radiographs and photographs) of 823 pediatric patients from Caracas.

Children with syndromes, systemic disorders, or clefts were excluded. The prevalence of supernumerary teeth was 5.47%, and the male:female ratio was 1.8:1. The most frequent shape was conical (45%), and the most frequent location was the anterior apical area (90%). Most (73.33%) patients had one supernumerary tooth, 22.22% had two, and 4.44% had three.

Table 2. Reported prevalence of supernumerary teeth, radiographically assessed

Study	Number of subjects	Supernu-merary teeth prevalence	Female/Male	Shape	Location
Mendez and Contreras, 2006	397	1%		-	Anterior apical
Iglesias, Manzanares and Valdivia, 2007	97	5.15%	M>F	-	-
Medina and Martínez, 2011	550	4.55%	M>F	Conical	Anterior apical
Jiménez de Sanabria et al., 2012	823	5.47%	M>F	Conical	Anterior apical

Dental Fluorosis: The prevalence of dental fluorosis is highly variable throughout Venezuela. Arellano, Fleitas and Ramírez (1998) reported an extremely high prevalence of fluorosis (98.60%) in children from two communities in the Zulia State on the northwestern coast who consumed well water almost exclusively. A more recent study in the same state found a 75.6% fluorosis prevalence in 1,010 children aged 7 to 12 years: 16.3% had moderate fluorosis, and 22.5% had severe fluorosis (Santana Pérez et al., 2012). There was a linear relationship between dental fluorosis and fluoride exposure from drinking water.

Montero et al. (2007) determined the fluorosis prevalence in Vargas State, which is located on the central coast. Overall, 421 children aged 8 to 11 years, from three different communities, were screened. In addition, fluoride concentrations in water and salt samples were determined. The fluorosis prevalence was 16.6%, and most cases were mild (8.5%). Fluorosis prevalence correlated with water fluoride concentrations. The fluoride concentrations in the three communities were 0.13 ppm, 0.31 ppm, and 1.58 ppm, and the corresponding prevalence of each was 11.22%, 3.36%, and 41.51%.

In the Merida State, in the Andean region, a fluorosis prevalence of 25% was reported by Medina et al. (2010), who screened 92 children, aged 6 to 14 years. Most cases were mild. Agreda, Simancas and Salas (2012) screened 445 children, aged 5 to 14 years, and reported a prevalence of 19.3%. The most frequent presentation was classified as doubtful to very mild. A similar result was reported by Agreda et al. (2013), who screened 340 6-12-year-old children in three communities in this state. The prevalence of fluorosis was 12%, and the most frequent type was classified as doubtful to very mild.

Table 3. Reported prevalence of dental fluorosis

Study	Number of subjects	Subject ages (years)	Fluorosis preva-lence	Water flouride concentration (ppm)	Fluorosis type (Dean Index)
Arellano, Fleitas and Ramírez, 1998	500	10-13	98.60%	-	Moderate
Montero et al., 2007	421	8-11	11.22% 3.36% 41.51%	0.13 0.31 1.58	Mild to very mild
Medina et al., 2010	92	6-14	25%	-	Very mild
Agreda, Simancas and Salas, 2012	445	5-14	19.3%	-	Doubtful to very mild
Santana Perez et al., 2012	1,010	7-12	75.6%	-	Moderate to severe
Rojas-Sánchez et al., 2012	187	2-62	66.6% 94% 93% 68.6%	0.99 1.05 1.36 1.92	Moderate
Agreda et al., 2013	340	6-12	12%	-	Doubtful to very mild

In 2012, Rojas-Sánchez et al. determined the prevalence and severity of dental caries and fluorosis in an endemic area of the Portuguesa State which is located in the central plains region. They screened 187 subjects, aged 2 to 62 years, who resided in four communities in the Santa Rosalía municipality. The fluorosis prevalence was 76.9%; the moderate form was most common. The authors concluded that water defluoridation should be a high priority in those communities.

Other dental anomalies: Few studies have examined the prevalence of anomalies of tooth size, shape, and structure in Venezuela. Iglesias, Manzanares and Valdivia (2007) conducted a clinical and radiographic survey in the Andean state of Merida and reported these anomalies: hypoplasia (10.31%), hypocalcification (8.25%), macrodontia (6.19%), fusion (4.12%), microdontia (2.06%), and gemination (1.03%).

Gaps and Recommendations

Tooth development and emergence in Venezuela appear to be similar to those seen in other countries around the world. The results of Venezuelan studies, however, may be skewed because they have been largely limited to radiographic reviews, and radiographs are not usually performed on children from lower socioeconomic strata. Radiographic assessments alone do not control for the effects of malnutrition or poverty on dental formation and tooth emergence.

The results of dental anomaly studies have been limited by the small number of patients screened. Hence, little is known about the effects of ethnicity and socioeconomic status on the epidemiologic profile of anomalies. Robust and comprehensive studies on dental development are needed in Venezuela.

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Yemen

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Background Information on Yemen

Yemen is in the southwest of the Arab peninsula and of Asia. It is in the Middle East, bordered on the west by the Red Sea and the Bab-el-Mandeb Strait, on the north by Saudi Arabia, and on the northeast by Oman, as shown in Figure 1. Yemen has been in a conflict state since 1970, when the southern government adopted a Marxist orientation. The massive exodus of hundreds of thousands of Yemenis from the south to the north contributed to two decades of hostility between the states. The conflict was resolved in 1990 after communist South Yemen and traditional North Yemen merged. However, the merger has not removed the tension between the northern and southern parts of the country (Index Mundi, 2018).

Yemen has five types of geographical terrain: plains, plateaus, mountains, desert, and the coast. It is divided into three main regions; the highlighted areas on the map represent most of the middle and north of the country. The coastal area, which is approximately 2,000 km, extends to the west and south, and the desert area covers most of the eastern governorates, especially Hadramout. Sana'a is the national capital for the Republic of Yemen. Taiz is the educational capital, where there are many academic and research centers. Aden, in the south, is the economic capital; it was the national capital of southern Yemen before 1990. The country was thrown into fresh crisis in 2011, inspired by the Arab Spring uprisings in Tunisia and Egypt. Despite peace initiatives, it spiraled into civil war in 2014, leading to a large-scale humanitarian crisis in the country. Further attempts at peace have failed, and the divisions between northern and southern Yemen have deepened (Index Mundi, 2018).

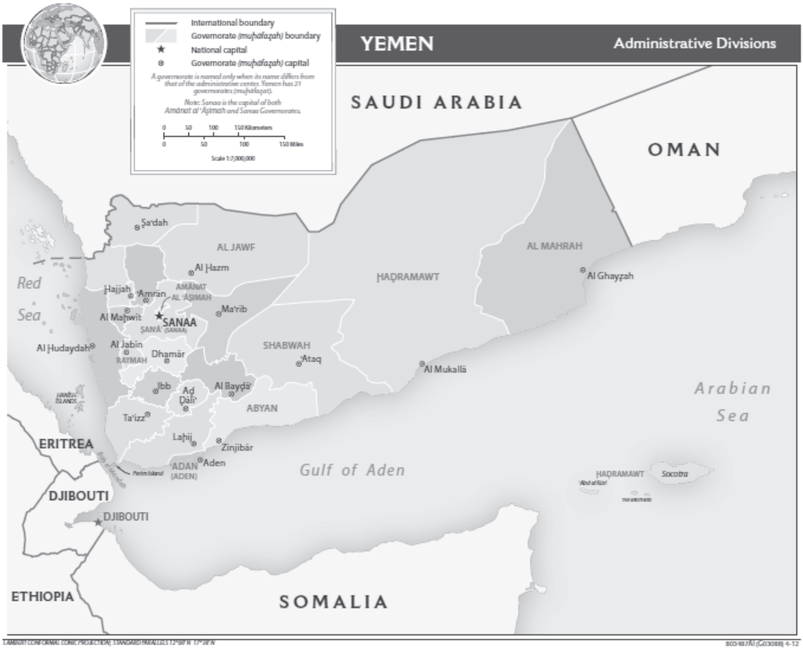

Figure 1: Map of Yemen

Yemen has one of the highest birth rates in the world (Rahimah and Rasheed, 2010). It also has a relatively young population, with 39.8% of its population being under 15 years of age. Life expectancy is 65.9 years (Index Mundi, 2018). The country has low levels of education, literacy, health services and socioeconomic status. There are no national data on oral health or dental development. Available information is limited to small studies conducted by academics in the few dental schools located in some cities in the country.

Sequence and Timing of Eruption of Primary and Permanent Dentitions

No data on the sequence and timing of eruption of primary and permanent dentitions in Yemen are available.

Developmental Dental Hard-tissue Anomalies

Baroudi and Basalamah (2016) screened 1,000 schoolchildren – 500 boys and 500 girls – from various areas of Sana'a city for developmental dental hard-tissue anomalies. As illustrated in Table 1, they identified 77 (7.7%) cases of dental anomalies, with the most prevalent lesion being enamel hypoplasia (2.8%). No girls had fusion, gemination, or supernumerary teeth, whereas boys had these anomalies, and they had a higher prevalence of enamel hypocalcification and enamel hypoplasia.

Table 1. Number of developmental dental anomalies in 1000 schoolchildren screened in Yemen

Dental anomalies	Boys n (%)	Girls n (%)
Dental fusion	2 (0.4)	0 (0.0)
Dental gemination	2 (0.4)	0 (0.0)
Dental transposition	1 (0.2)	2 (0.4)
Supernumerary teeth	3 (0.6)	0 (0.0)
Hypodontia	2 (0.4)	2 (0.4)
Macrodontia	3 (0.6)	1 (0.2)
Microdontia	3 (0.6)	2 (0.4)
Enamel hypocalcification	22 (4.4)	4 (0.8)
Enamel hypoplasia	20 (4.0)	8 (1.6)

Balkees (2006) screened 1,000 secondary school female students aged 14-21 years resident in Thamar (Table 2). The prevalence of anomalies of structure, shape, size and number in the permanent dentition was determined. The most prevalent anomaly of tooth structure was fluorosis (10.8%), while the most prevalent anomaly of tooth size was microdontia (1.8%). Hypodontia (3.2%) was the most prevalent anomaly related to the number of teeth. The only shape-related anomaly identified was talon cusp, in a single person.

Fluorosis

Deep well water, the main source of drinking water in Yemen, especially in rural areas, has very high fluoride concentrations – 2.5 to 32 milligrams (Kadir and Al-Maqtari, 2010). Naser et al. (2016) conducted a survey on fluoride concentration in ground water and found that many districts of Sana’a, Taiz, Ibb, Dhamar, Raimah and Al-Dhalei, had high concentrations; the highest concentrations were found in some of the Sana'a governorate districts, particularly in Sanha.

Table 2. Developmental dental hard-tissue anomalies in female secondary school students (N=1,000)

Development disturbances in teeth	No.	%
Structure		
Fluorosis	102	10.2
Enamel hypoplasia	2	0.2
Enamel hypocalcification	8	0.8
Amelogenesis imperfecta	2	0.2
Size		
Microdontia	18	1.8
Macrodontia	2	0.2
Shape		
Talon cusp	1	0.1
Number		
Supernumerary	2	0.2
Hypodontia	39	3.9

Table 3 provides details on the type and prevalence of the missing teeth in the dental arch. The most prevalent missing tooth was the maxillary right lateral incisor, followed by the maxillary left lateral incisor. The maxillary second premolars and the maxillary right central incisor were the least missing teeth (Balkees, 2006).

Table 3: Type and prevalence of missing teeth (N=39)

Tooth	No.	%
Maxillary right lateral incisor	16	41.0
Maxillary left lateral incisor	10	25.6
Maxillary canine	6	15.4
Mandibular left lateral incisor	3	7.69
Mandibular right lateral incisor	2	5.13
Maxillary second premolar	1	2.56
Maxillary right central incisor	1	2.56

Gaps and Recommendation

Data on dental health are needed and essential for planning. Sadly, the continued humanitarian crisis in Yemen makes it difficult to conduct research and collect quality data, but there is a clear need for more oral health-related information. Also, the high level of fluoride in the drinking water may be associated with other pathologies not yet described. Water de-fluoridation is an essential need in Yemen; otherwise, citizens are advised about an alternative source(s) of drinking water, especially in the rural areas.

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OROFACIAL CLEFTS: EPIDEMIOLOGY, ETIOLOGY, AND TREATMENT

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Introduction

The face is the most visible structure of the body, and birth defects in this region are easily recognized. The most common facial birth defects that are sentinel to other birth defects are orofacial clefts. Orofacial clefts are defined as the incomplete closure of the lip and palate during embryonic and fetal development. These defects affect 1 in 700 live births worldwide (Mossey and Modell, 2012). Most orofacial clefts have associated speech, hearing, and respiratory problems, and they can adversely affect swallowing and feeding, which may lead to malnutrition and retarded growth and development.

Orofacial clefts are amenable to surgical repair. In addition to repair, patients often require restoration of speech, esthetics, and function. Orofacial clefts also may have associated psychological trauma for both the child and the family. In some cases, the child and family may be ostracized from their communities. Therefore, children and families affected by orofacial clefts may require support for integration into communities.

The costs associated with the management of patients with orofacial clefts can be extreme. In the US, it is estimated that the lifetime cost of

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managing a child with an orofacial cleft is about $100,000 (Waitzman, Romano and Scheffler, 1994). This cost could be more in developing countries, where social and physical infrastructures are limited. For instance, surgical care funded by non-profit organizations in developing countries costs as much as $250 per person (Brydon et al., 2014).

Epidemiology and Types of Orofacial Clefts

Historically, orofacial clefts are classified as cleft of the lip only, cleft of the palate only, and cleft of the lip and palate (Marazita et al., 2012). Clefts can also be classified as unilateral and bilateral and as non-syndromic and syndromic.

The prevalence of clefts varies across ethnic groups because of the genetic and environmental influence on their expression. The prevalence is 1/1000 in Europe (Long et al., 1992), 1.4/1000 in Asia (Dai et al., 2010), and 0.5/1000 in Africa (Butali et al., 2014). The prevalence of orofacial clefts is highest in Japan (25.79/10,000), Australia (20.86/10,000), Mexico (15.86/10,000), USA – Atlanta (14.92/10,000), Chile (14.17/10,000), Cuba (6.6/10,000) and Spain (6.55/10,000) (ICBDSR, 2011). The ratio of oral clefts in Puerto Rico is 15.9/10,000 live births (PR Department of Health, 2012), which is one of the highest among Latinos.

The risk of occurrence of orofacial clefts is 32 times greater for families that have at least one child with a cleft than for the general population. There is also a 23% chance of having a second child with orofacial clefts in a family with a history of clefting (Sivertsen et al., 2008). A family with one cleft phenotype is more likely to have additional offspring with the same phenotype than the general population – bilateral cleft lip has a 4.6% risk and cleft palate has a 3.9% risk (Grosen et al., 2010).

Subclinical phenotypes of orofacial clefts: Certain subclinical types of orofacial clefts can be diagnosed after thorough clinical examinations and the use of advanced technological devices. One type is a discontinuity in the orbicularis oris muscle. Its prevalence is greater in families with a history of orofacial clefts than in the general population (Neiswanger et al., 2007). Hypodontia is a subclinical cleft phenotype of orofacial clefts (Hermus et al., 2013; Mikulewicz et al., 2014; Jamilian et al., 2015). Unaffected relatives of individuals who have clefts have a greater genetic risk for clefting than the general population (Suzuki et al., 2009). Studies of these conditions have provided evidence on the role of genetics as a predisposing factor for phenotypes and subclinical forms of orofacial clefts.

Dental anomalies associated with orofacial clefts: In addition to hypodontia, other dental anomalies have been reported in persons with orofacial cleft, including malformations of the dimension, morphology, number, and eruption patterns of teeth (Vibhute et al., 2013). Other anomalies are microdontia (small teeth) and missing teeth, where less than 6 teeth are missing; oligodontia, where six or more teeth are missing, and anodontia, where all the teeth are missing.

Missing teeth (hypodontia, oligodontia and anodontia) and microdontia are the most prevalent dental anomalies in individuals with orofacial cleft (Al Jamal, Hazza'a and Rawashdeh, 2010; Wangsrimongkol et al., 2013; Paranaiba et al., 2013; Al-Kharboush et al., 2015; Sa et al., 2016; Konstantonis et al., 2017; Ajami et al., 2017). While a few authors have shown that there is an increase in the number of dental anomalies as the severity of orofacial clefts increases (Al Jamal, Hazza'a and Rawashdeh, 2010; Wngsrimongkol et al., 2013), others have not substantiated this correlation (Paranaiba et al., 2013; Sa et al., 2016). Therefore, dental anomalies associated with orofacial clefts may be due to a combination of environmental pollutants, in which the development of clefts affects tooth development, and genetic risk, where a common genetic risk locus results in both orofacial clefts and these dental anomalies (Phan et al., 2016).

Risk Factors for Cleft Lip with or without Cleft Palate

Orofacial clefts are complex traits and multi-factorial in origin. Several genetic and environmental factors increase the risk for these phenotypes. This section describes some of the genetic, genomic, and environmental factors that have been reported to increase the risk for cleft.

Genetics and Genomics: Linkage was used to map the locus for van Der Woude syndrome (Murray et al., 1990). This syndrome is the most common syndromic cleft, accounting for 2% of all orofacial clefts. It is characterized by orofacial clefts and bilateral lower lip pits that are inherited in an autosomal dominant fashion and are highly penetrant in affected families (Lam et al., 2010).

Mutations in the *IRF6* gene, accounting for 75% of van Der Woude syndrome (OMIM: 119300) and popliteal pterygium syndrome (OMIM: 119500), were first reported by Kondo et al. in 2002. Resequencing of the *IRF6* gene in non-syndromic orofacial clefts (a phenocopy of van Der Woude syndrome) identified a missense mutation in *IRF6* (p.Val247Iso), which was found more in non-syndromic clefts than in controls, and this mutation was significantly inherited in affected families (Zucchero et al., 2004). Over 300 *IRF6* mutations have been reported for van Der Woude syndrome and popliteal pterygium syndrome (De Lima et al., 2009; Leslie et al., 2013; Butali et al., 2014; Gowans et al., 2017).

In 2014, a second gene for van Der Woude syndrome – Grainyhead-like 3 (GRHL3) – was reported (Peyrard-Janvid et al., 2014). This gene accounts for 5% of all van Der Woude syndrome cases. GRHL3 encodes the transcription factor Grainyhead-like 3, which is necessary for the formation of the epidermal permeability barrier in mice (Ting et al., 2005). GRHL3 and IRF6 are necessary for differentiation of the oral periderm, the most superficial layer of oral epithelium, which covers palate shelves during morphogenesis of the face (Ingraham et al., 2006; Peyrard-Janvidet et al., 2014). Loss of the oral periderm results in adhesions between the palate shelves in mice (Richardson et al., 2009) and leads to defective differentiation of the oral periderm. This cellular event ultimately results in cleft palate.

In 2008, Rahimov et al. reported an association between non-syndromic clefts and a single nucleotide polymorphism in an *AP2* alpha-binding site near the *IRF6* gene. A functional study confirmed that this enhancer is expressed in the same craniofacial structures as the *IRF6* gene. Genome-wide association studies confirmed the role of *IRF6* in non-syndromic orofacial clefts (Birnbaum et al., 2009; Mangold et al., 2010; Beaty et al., 2010, Ludwig et al., 2012). These observations support the role of *IRF6* as a clefting gene.

FOXE1 is also a cleft candidate. It was discovered through genome-wide linkage scans and family-based association studies (Marazita et al., 2004; Moreno et al., 2009). A Genome-wide association study confirmed significant association for single nucleotide polymorphism in *FOXE1,* thus providing evidence that this gene is involved in the etiology of cleft lip and palate (Ludwig et al., 2014). Genome-wide association studies identified significant signals in *MAFB* and near significant loci in *Pax7* and *VAX1,* which have been replicated in multiple populations (Mangold et al., 2010; Beaty et al., 2010, Butali et al., 2013, Nasser et al., 2013).

In 2012, *ARHGAP29* was first reported as a cleft candidate gene after resequencing was performed around *ABCA4,* a genome-wide association study-candidate gene (Beaty et al., 2010; Leslie et al., 2012). A meta-analysis of genome-wide association studies replicated previous findings and identified six new candidate loci (Ludwig et al., 2012). The Chr8q.24 locus has been reported to be significantly associated with non-syndromic orofacial clefts in genome-wide association studies with samples from populations of European descent (Birnbaum et al., 2009; Grant et al., 2009; Mangold et al., 2010; Beaty et al., 2010; Ludwig et al., 2012). A genome-wide association study in a Chinese population identified a new susceptibility locus for non-syndromic clefts at the Chr16p13.3 locus between the *CREBBP* and *ADCY9* genes (Sun et al., 2015). Another Chinese genome-wide association study identified 14 novel risk loci (Yu et al., 2017). To date, seven genome-wide association studies for cleft lip with or without cleft palate and two genome-wide association studies for cleft palate only have been published, and over 40 risk loci have been identified (Beaty, Marazita and Leslie, 2016).

Evidence from cleft genome-wide association studies reveals that some loci are population specific, whereas other loci have associations with multiple populations (Beaty et al., 2010). This difference is mainly due to differences in allele frequencies and population specificity. For example, the orofacial-cleft risk loci were identified at the chr8q.24 locus in Caucasians from Europe and North America and at *MAFB* in Asians (Beaty et al., 2010). Also,15q22 reached genome-wide significance in Europeans and Mexicans but not in Asians (Ludwig et al., 2014; Ludwig et al., 2016); 16p13.3 is significant only in Chinese (Sun et al., 2016); and 2p13.1 is significant in Native Americans and not in Europeans or Asians (Masotti et al., 2017). Considering the successes of cleft genome-wide association studies in identifying new risk, similar studies in Africa may lead to the discovery of new risk loci, which can be used to fine-map risk loci identified in populations of European and Asian ancestry. A recent meta-analysis of epigenome-wide association studies from 13 cohorts (n=6685) identified twenty-seven genes that have been associated previously with orofacial clefts; these include VAX1, NOG, BMP4, and MSX1 (Joubert et al., 2016).

Targeted resequencing efforts around genome-wide association and known clefting genes have identified *de-novo* damaging functional mutation in *PAX7* and non-coding functional mutations near *NOG* and *FGFR2* (Leslie et al., 2015). Several other candidate genes have been reported for non-syndromic clefts, such as *MSX1* and *BMP4* (Sakatoka and Maas, 1994; Jezewski et al., 2003; Suzuki et al., 2004, Suzuki et al., 2009; Butali et al., 2011); *SUMO1* (Alkuraya et al., 2006); *TGFα* (Lu et al., 2014) and *TFGβ* (Ardinger et al.,1989).

Environmental Factors: Environmental factors may increase the risk of orofacial clefts independently or in the context of other factors, including environment-environment and gene-environment interactions. Environmental risk factors for orofacial clefts can be categorized into 1) maternal health and behavior, 2) medical history, and 3) nutritional status of the mother during the periconceptional period. The following are some of the identified risk factors.

Maternal cigarette smoking: Maternal smoking during pregnancy is the strongest known environmental risk factor for orofacial clefts. Maternal smoking is a direct teratogen or a teratogen on the maternal genome resulting in an epimutation that can lead to orofacial clefts. A meta-analysis by Little, Cardy and Munger (2004) that included 24 studies, reported a consistent, moderate, and statistically significant association between maternal smoking and both cleft lip (OR = 1.3, 95% CI: 1.3-1.4) and cleft palate (OR = 1.2, 95% CI: 1.1-1.4). Mossey, Davies and Little (2007) reported that the risk of orofacial cleft for the child of a woman with an unplanned pregnancy who smoked is nearly 3 times greater than the risk for a non-smoking mother with a planned pregnancy (OR = 2.9, CI: 1.5-5.7). In a case-cohort study, Bille et al. (2007) found that Danish women who smoked during their first trimester have a statistically significant greater risk (OR = 1.50, 95% CI: 1.05-2.14) for oral clefts. In 2013, Butali et al. reported a statistically significant association between maternal smoking and both isolated cleft lip with or without palate and cleft palate in individual participants' data analysis by using case-control data from four European studies. Passive smoke exposure also increases the risk for orofacial clefts (Shaw et al., 1996; Little, Cardy and Munger, 2004; Honein et al., 2007).

Maternal alcohol consumption: Alcohol is a teratogen that can affect the normal migration of embryonic neural crest cells and the development of craniofacial structures. High alcohol intake is a putative risk factor for orofacial cleft. Werler et al. (1991) found that the risk of cleft lip and palate was three times greater among those reporting more than five alcoholic drinks per day than those drinking less than once per day. No association was found between cleft palate and alcohol consumption. Those who had four or more drinks per month had a 3- to 4-fold statistically significant increased risk for non-syndromic cleft lip and palate compared to those who drank no alcohol (Munger et al., 1996). Shaw and Lammer (1999) also found that frequent binge drinking was associated with cleft lip and palate, whereas lower levels of intake were not associated with cleft lip and palate. DeRoo et al. (2008) found that binge drinking (more than 5 drinks per sitting) increased the risk of cleft lip and palate and cleft palate. Estimated risks were higher for women with frequent binge drinking. Lorente et al. (2000) found that women who drank alcohol on weekend days during the first trimester had an increased risk (OR = 2.28, 95% CI: 1.02-5.09) for cleft palate. Grewal et al. (2008) reported an increased risk for cleft lip and palate with congenital anomalies irrespective of the level and frequency of alcohol intake. There are, however, studies that did not find associations between maternal alcohol intake during the periconceptional period and an elevated risk for orofacial clefts (Bille et al., 2007, Romitti et al., 2007).

***Nutrition**:* Vitamins and trace elements are important in embryonic development, including palatogenesis (Ackermans et al., 2011). While a combination of genetic and environmental factors contributes to the expression of cleft lip and palate (Mossey et al., 2009), the mother's nutritional intake as well as variations in the genes responsible for nutrient transfer and metabolism (Mossey et al., 2009) are equally important. Numerous studies have examined micronutrients and nutrition in orofacial clefts. A higher-quality diet (Carmichael et al., 2012) and certain micronutrient-dense foods, such as liver (McKinney et al., 2013), may decrease oral- cleft risk. Caffeine intake does not increase the risk for oral cleft (Browne, 2006; Johansen et al., 2009). Excess or deficiency of certain nutrients has been associated with cleft lip and palate, but the evidence for this is limited (Mossey et al., 2009). Periconceptional multivitamin use is associated with a 22% to 49% decreased risk of oral cleft. It is, however, unclear whether this decrease is associated with a specific micronutrient or a combination of micronutrients (Johnson and Little, 2008; Butali et al., 2013).

Folic acid is the most-studied micronutrient risk factor for oral clefting. Folic acid and its anionic form, folate, are forms of water-soluble vitamins involved with the production and maintenance of new cells during periods of rapid cell division and growth (Chattopadhyay and Wahl, 2010), which are important processes in embryogenesis and pregnancy. Folate is also involved in DNA methylation, leading to the activation and expression of genes involved in craniofacial development (Piedrahita et al., 1999). We postulate that epigenetic processes can lead to birth defects in the presence of an epimutation in the folate pathway. This assumption will be discussed in detail in the *Epigenetics* sub-section of this chapter. Folate is required to synthesize thymine and purine bases that are needed for DNA replication (Li et al., 2017). Therefore, folate deficiency may hinder DNA synthesis and cell division.

Adequate folate intake during the periconceptional period helps protect against congenital malformations, including cleft lip and palate. The risk of neural tube defects is significantly reduced in women who take 0.4 mg of supplementary folic acid in addition to a healthy diet before, to and during the first month after conception (Czeizel and Dudas, 1992). However, the reports on the role of folic acids in cleft prevention are inconsistent, and different measures of folic acid (dietary folate, folic acid supplementation, blood biomarkers measures of folate) complicate the interpretation of the evidence. Some studies suggest that high levels of folic acid reduce the risk for oral cleft (van Rooij et al., 2004; Munger et al., 2011; Butali et al., 2013), whereas others provide little support for this assertion (Johnson and Little, 2008). One study found that the risk for cleft lip and palate was four times greater for offspring of mothers who did not take folic acid than for mothers who had taken folic acid in early pregnancy (Kelly, O'Dowd and Reulbach, 2012). From a population perspective, the birth prevalence rate of orofacial clefts in North America declined less than 6% after the mandatory folic acid fortification of flour in 1998 (Ray et al., 2003; Yazdy, 2007). This observation suggests that although low folate may be a risk factor for orofacial clefts, it may account for only a small proportion of the defect.

Maternal obesity and diabetes mellitus: Obesity is a metabolic disorder that affects maternal health and appears to be associated with embryonic development. Obesity may also be a marker for maternal malnutrition (nutrient-poor diet), which may act independently or jointly with other environmental or genetic factors to increase the risk for orofacial cleft. Increased risk for orofacial clefts in obese women (body mass index greater than or equal to 28) has been reported in several studies (Queisser-Luft et al., 1998; Moore et al., 2000; Cedergren and Kallen, 2005; Stott-

Miller et al., 2010). The risk was greater for orofacial clefts with associated malformations than for isolated orofacial clefts. Furthermore, obese women are at an increased risk of developing diabetes. Therefore, the association between maternal obesity and orofacial cleft may be due to undetected Type 2 diabetes mellitus (Becerra et al., 1990). This matter requires further attention by investigating the maternal nutritional biomarkers and metabolic syndrome in various populations.

Epigenetics: The state of the epigenome is relevant to the etiology of diseases. The epigenome is independent of genetic variations, and its role has been well-established in cancer, obesity, and diabetes (Keil and Keil, 2015; Wahlqvist et al., 2015). The impacts of variations in DNA methylation and acetylation, otherwise known as epi-mutations, can be seen beyond three generations (El Hajj et al., 2014). The role of folic acid, maternal smoking, and alcohol in clefting is not understood. One possibility is that these environmental factors are imprinted on the maternal genome and inherited by the developing embryo, leading to craniofacial malformations. Folate has a significant impact on DNA methylation and the activation of some genes that may be critical during craniofacial development. An approach that needs to be explored in cleft studies is the examination of methylation patterns in cleft individuals and families; this approach could improve our understanding of the mechanisms underlying the etiology and development of orofacial clefts.

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A Review of the Teething Phenomenon

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Introduction

Tooth eruption is a natural physiologic process of childhood. During eruption, the teeth move from their developmental position in the alveolar bone and penetrate the mucosa into the oral cavity (Cahill, 1980). Emergence of primary teeth usually starts between 4 and 10 months of age and is completed by about 30 months (Markman, 2009).

Emergence of the first tooth is an important milestone that happens simultaneously with several ongoing physiological processes. The salivary glands develop at about 2 to 3 months of age, when they contribute to constant drooling of saliva (Leung and Kao, 1999). At about 6 months of age, when the first primary teeth are about to erupt, maternal antibodies that the child acquired from its mother begin to decrease as the child builds up its own antibodies. The child then is highly susceptible to infection (McIntyre and McIntyre, 2002). This is also the time when the child starts to crawl, pick up objects, and explore things by placing them in the mouth (Kakatkar et al., 2012). In tropical countries, such as Nigeria, this time also tallies with the first clinical malaria infection in children (Achidi et al., 1996; Nwuba et al., 2002). At 8 or 9 months of age, night waking occurs; infants develop a sense of object permanence and call out to their parents at night (Anderson, 2004). It may then be assumed that the saliva drooling, gastrointestinal disturbances (diarrhea, vomiting, increases in temperature) that may result from putting objects in the mouth with dirty hands while crawling, and the restlessness from night waking are due to the emergence of the first set of primary teeth. Frederic Still noted in 1927 the possibility that symptoms and teething are a coincidence, not a causal relationship (Rendle-Short, 1955).

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Teething was associated with multiple symptoms and mortality until the late 19th century, when evidence started to emerge that teething is a harmless physiological process: Macknin et al. (2000), in a prospective study, failed to find a cluster of symptoms associated with tooth emergence; Wake, Hesketh and Lucas (2000) found only a weak association between tooth emergence and symptoms attributed to teething; and Jaber, Cohen and Mor (1992) found no association between teething and fever. Attributing symptoms such as fever and irritability to teething increases the risk of missing significant illness and severe morbidity and mortality (Wake and Hesketh, 2002), especially in communities where the risks for diarrhea and septicemia are high. Healthcare professionals buying into this misconception increase the risk of child mismanagement (South, 2003).

The History of the Fable of Teething

Rendle-Short (1955) traced the history of teething to ancient Greece. So entrenched was the belief that tooth emergence was not a physiological process, that when contradictory evidence started emerging, as far back as 1889, older physicians cautioned against the exuberant presumptions of younger colleagues. Hippocrates in his writings, in c. 400 BC (no. 25), claimed that children experiencing teething suffered from itching gums, fever, convulsions and diarrhea, especially when cutting their canines (Rendle-Short, 1995; Ashely, 2001). In 1839, 5,016 child deaths in England and Wales were attributed to teething (Registrar's General Report, 1911). In 1894, Dr Thrasher, a well-known dentist, wrote in *Dental Cosmos*, "So deadly has teething become that one third of the human family die before 20 deciduous teeth have fully appeared" (Ashely, 2001). The condition was known as *Dentitio Difficilis*. The proscribed treatment was lancing of the gum – a procedure that required great skill (Harris, 1689) and was associated with high fatality (Rendle-Short, 1995).

The possibility that teething was not responsible for the symptoms ascribed to it was first expressed by William Cadogan, in 1747, and George Armstrong concurred with him (Armstrong, 1784). Poor understanding of nutrition, infection, infectious organisms and infection control made it easy to attribute the numerous causes of infant and neonatal mortality to teething (Rendle-Short, 1995). Gradually, though, it was appreciated that diarrhea could be attributed to poor-hygiene feeding practices; convulsion to numerous febrile diseases, such as smallpox and meningitis; and oral symptoms to scurvy or mercury poisoning (Rendle-

Short, 1995). Baykan et al. (2004) proclaimed the plausibility of these realities when they showed that 78.8% of symptoms attributed to teething were related to bacterial infection in 7.1% of cases.

Nonetheless, mild symptoms, such as gum rubbing, gingival irritation, digit sucking and slight increases in body temperature may be associated with teething (Wake, Hesketh and Lucas, 2000). Teething also may be associated with mild daytime restlessness, thumb sucking, gum rubbing, drooling and temporary loss of appetite (Leung, 1989). A meta-analysis highlighted irritability and drooling as frequent symptoms associated with teething (Massignan et al., 2016).

The myths of symptoms associated with teething persist not just in Australia, Canada, the United Kingdom, and South Africa (John, 2003) but also in Asia (Kakatkar, 2012), South America (Feldens et al., 2010), the middle East (Baykan et al., 2004; Sarrell et al., 2005) and Nigeria (Oyejide and Aderinokun, 1991; Uti, Savage and Ekanem, 2005; Ozeigbe et al., 2009; Adimorah, Ubesie and Chinawa, 2011; Agbaje et al., 2012; Ige and Olubukola, 2013; Adams et al., 2015; Bankole and Lawal 2017; Bankole, Lawal and Balogun, 2017). Laypersons associate teething with symptoms such as fever (Oyejide and Aderinokun 1991; Uti, Savage and Ekanem, 2005; Baykan et al., 2004; Sarrell et al., 2005; Ozeigbe et al., 2009, Adams et al 2015), vomiting (Oyejide and Aderinokun, 1991; Uti, Savage and Ekanem, 2005; Ozeigbe et al., 2009) and loss of appetite (Uti, Savage and Ekanem, 2005). Other signs or symptoms ascribed to teething are cough (Uti, Savage and Ekanem, 2005), colds/catarrh (Uti, Savage and Ekanem, 2005) ear infection (Sarrell et al., 2005; Adams et al., 2015), weight loss (Sarrell, 2005; Feldens et al., 2010; Kakatkar et al., 2012), conjunctivitis (Oyejide and Aderinokun, 1991) and headache (Oyejide and Aderinokun, 1991). Younger mothers and less educated persons are most likely to associate symptoms with teething (Ige and Olubukola, 2013; Bankole and Lawal, 2017).

However, many health care professionals also believe there is an association between some signs and symptoms and the eruption of primary teeth. Pediatricians (Honig, 1975; Wake and Hesketh, 2002; Faraco, 2008), nurses (Wake and Hesketh, 2002; Bankole, Denloye and Aderinokun, 2004; Sarrell et al., 2005), community health officers (Denloye, Bankole and Aderinokun, 2005), pharmacists (Wake and Hesketh, 2002) and traditional-birth attendants (Bankole, Taiwo and Adesakin, 2013) may hold these beliefs.

Fallacious Treatment of Teething

In the 6th century, treatments for teething included eating or putting hare brains on the gums, drinking dog's milk, and using charms and amulets. In the 18th and 19th centuries, purgatives and emetics were the preferred treatments. Other common remedies were toxic substances, such as opiates, lead, mercury salts, and bromide. Also, honey and salt were used. Lancing the gums became widely accepted and was considered lifesaving, as autopsies of children revealing unerupted tooth buds fed the belief that teething was responsible for their deaths (Markman, 2009). In more recent times, mothers have used self-prescribed pharmacological and non-pharmacological remedies, such as analgesics, teething powder and syrup, sedatives, antibiotics, teething toys, and herbal medications (Adams et al., 2015) to treat conditions believed to be caused by teething.

Analgesics: Analgesics, mainly paracetamol, are popular remedies for teething symptoms (Bankole, Lawal and Balogun, 2017; Opeodu and Denloye, 2014; Katatkar et al., 2012). Whilst paracetamol may be essential to lower body temperatures in febrile conditions, its use may conceal more serious underlying illnesses. Also, overdosing with paracetamol can cause hepatocellular necrosis, renal tubular necrosis and death (McIntyre and McIntyre, 2002), and ibuprofen frequently causes adverse reactions in children (Tsang, 2010). Choline salicylates applied topically irritate sensory nerve endings, cause vasodilatation, and alter pain sensation in tissues served by the same nerve (Mason et al., 2004). Like aspirin, these salicylates may induce Reyes Syndrome, especially in infants or children recovering from viral infections (Tsang, 2010).

*Antibiotic*s*:* In Nigeria, tetracycline is the antibiotic of choice for many members of the lower social class, and it is popularly prescribed for the treatment of "teething diarrhea." A major problem with tetracycline use is the greyish discoloration it causes in actively calcifying tissues such as the teeth (Sánchez, Rogers and Sheridan, 2004). Aderinokun et al. (1994) have reported that over a third of 12-year-old children in Ibadan, Nigeria, had stained teeth, caused by tetracycline consumption in childhood. Antibiotics can be purchased over the counter or from local drug peddlers in some developing countries.

Teething powder, teething syrup and teething gels: These are favorite prevention and treatment options for teething symptoms (Bankole, Lawal and Balogun, 2017). Teething powder formerly contained mercury

(Shandley and Austin, 2011), but the mercury has been replaced with essential oils, mainly Matricaria chamomilla (chamomile) and lactose (Ashton and Parsons Infant Powders, 2015). Teething syrups contain a paracetamol base and, sometimes, antihistamines. Teething syrup and powders are unregulated and thus carry the risk of excessive dosing. An adulterated teething syrup, the paracetamol-based mixture in "My Pickin" teething syrup, was laced with diethylene glycol, an agent commonly used as an engine coolant; it led to the deaths of 84 babies in Nigeria in 2008 (Howden, 2009). Teething gels often contain the topical preparations, lignocaine and benzocaine for temporary pain relief; benzocaine poses a risk of hypersensitivity reaction and methemoglobinemia (Bong, Hilliard and Seefelder, 2009). These remedies presumably reduce inflammation at the teething site by cooling (McIntyre and McIntyre, 2002; Owais, Zawaideh and Bataineh, 2010). This is achieved by the constriction of dilated blood vessels and temporarily numbing the gingivae (Williams, 1976). The pressure from their being rubbed on the teething site and from chewing may reduce pain by overwhelming the sensory receptors (Steward et al., 1988).

Traditional herbal concoctions: Babies are often given traditional herbal concoctions to prevent or treat teething (Bankole and Lawal, 2017). Other concoctions are in liquid form and can be purchased from local hawkers (Bankole, Lawal and Balogun, 2017). The formulations and doses of these concoctions are unknown, and some may be hazardous to infants. They often are prepared locally through unhygienic practices, so the microbial contamination of some exceed tolerable limits (World Health Organization, 1998); Adeleye, Okogi and Ojo (1994) reported that many pathogenic organisms, such as *Staphylococcus aureus, Bacillus cereus,* and *Escherichia coli,* are present in these concoctions. Of concern are Staphylococcus-drug interactions that can occur when local traditional preparations containing high concentrations of ethanol are given to infants who also use paracetamol (Tsang, 2010). It is a common practice to soak herbal ingredients in alcohol to allow fermentation of the leaves and plant roots to produce the required potent extract.

Infant oral mutilation: Strong cultural beliefs hold that swelling in the area of the gums associated with the unerupted primary canine is a cause of persistent fever and diarrhea in infants; thus, the primary canine tooth buds are removed. The reported prevalence of this infant oral mutilation is 1% to 60% in Tanzanian villages; 16% in northern Uganda; 22% among urban children in Sudan; 59% among Ethiopian Jews; 70% in some populations in Ethiopia; 87% among the Maasai in Kenya; and 100% among infants younger than 18 months admitted to a hospital in southern Sudan (Baba and Kay, 1989). Typically, the tooth buds are removed with unsterile implements and without local anesthesia at the age of 4 to 18 months. Instruments used for these procedures include pieces of iron, hooked iron bars, razor blades, pen knives, nails, bicycle spokes, sharp fingernails, sharp thorns of the Orgosua tree, rusty wires, knitting needles, scissors, and pieces of broken glass. Post-operative wound applications include charcoal powder; ashes of herbs; lizard feces; crushed antibiotics; sulfur capsules; a warm poultice of butter, mustard and garlic; salt; sodium bicarbonate; herbs; a sugar solution of herbs in locally prepared medicinal powder; and honey (Gollings and Longhurst, 2013).

Palm oil and teething soap: In southwestern Nigeria, palm oil is prescribed because of the cultural belief that it neutralizes toxic substances and poisons. Mothers are asked to give their children palm oil to “neutralize” the processes that produce the teething symptoms. Similarly, black soap, a by-product of palm oil, is advocated to prevent teething symptoms when used to wash the gums. Often, the black soap is mixed with local herbs, particularly “eru,” which is considered medicinal (Bankole and Lawal, 2017).

Amulets: Charms are worn as wrist bands, amulets, bangles, or waist beads to prevent teething problems. The use of protective teething necklaces has a long history of practice (Taillefer, 2012), although it is associated with the risk of strangulation or aspiration of small beads by infants (Bankole, Lawal and Balogun, 2017). Herbalists and witch doctors may make incisions on the child’s skin to prevent teething maladies (Bankole, Lawal and Balogun, 2017).

Other folk remedies: Among other folk remedies used for treating symptoms associated with teething are Japanese wooden teething rings; German zwieback toast; the practice, in Africa and the Caribbean, of hanging a raw egg over the area where the baby sleeps; and India’s Ayurvedic use of cloves. Acupuncture for teething is practiced in traditional Chinese medicine. There are also Sophie the Giraffe, the teething toy produced in France since 1961, and the Baltic amber teething necklace, believed to contain anti-inflammatory and therapeutic substances that remove the “pain” of teething (Traditional teething remedies, 2015).

Gaps and Recommendations

Misconceptions and erroneous beliefs about teething can be dispelled by oral health education. Photo posters as an educational tool on teething can be effective (Bankole et al., 2002-2003), especially when used in an instructional and interactive atmosphere (Bankole, Aderinokun and Denloye, 2004). Videos are powerful communication and health-education tools. A twenty-four-minute video, produced in a local Nigerian language and pilot tested for use, has been effective in conveying the message on asymptomatic tooth eruption (Bankole, Lawal and Ibiyemi, 2018). It is important to facilitate the use of such educative materials in low-literate communities where fallacies about teeth emergence persist.

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Where there are No Data – Thinking of The Future of Tooth Anatomy and Tooth Anomaly Research

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Introduction

The number of erupted teeth and the timing and sequence of tooth eruption are important and reliable tools for estimating chronological age (Hassanali and Odhiambo, 1982; Kumar and Sridhar, 1990; De Souza and Hedge, 2018). Teeth are also suitable for the study of growth rates, developmental stress, time of crown formation, and age at death of juveniles (Smith, 2015). Teeth are less affected by hormonal disorders and malnutrition than bone, and they are better preserved and rarely change once formed (Hillson, 2014). Thus, teeth are the most reliable parts of

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fossils for estimating the chronological ages of remains since they survive well when buried (Hillson, 1996).

Teeth are important for studying growth rates because tooth tissues do not turn over; thus, incremental age-related changes are embedded in their layered tissue structures (Hillson, 2014). This feature of teeth makes the understanding of tooth anatomy important in disciplines such as forensic science, anthropology, archeology, pediatric dentistry, and orthodontics (Manjunatha and Soni, 2014).

Data on tooth eruption and emergence are used in medico-legal cases for determining the age of minors, particularly of those in the workforce (Al Balushi, Thomson and Al-Harthi, 2018) or unaccompanied refugees, should litigation arise (Schmeling et al., 2016). In clinical dental practice, the timing and sequence of tooth eruption provide a reference for diagnosis and treatment for pediatric and orthodontic patients (Debs and Sfeir, 2015). Since the data are derived from sample populations specific for various countries, the availability and accessibility of such data are vital, as emphasized by Esan and Schepartz (2019).

Data on developmental dental anomalies are just as important as data on the pattern of eruption and timing of emergence of teeth. Since tooth tissue does not turn over, imprints of diseases caused by disruption of tooth formation can be assessed years later. For example, growth disruption caused by fever and nutritional deficiencies leaves indelible imprints on teeth (Hillson, 2014). Knowledge of dental development and causes of developmental defects of teeth helps to clarify the origins and evolution of modern human life and in making inferences about human health through studies of archeological populations and fossil assemblages (Smith, 2015). Thus, global data on tooth eruption and sequence are an invaluable archive for studies on differences and commonalities between and within populations.

Tooth Development

Teeth are scarcely influenced by nutritional, endocrine and environmental factors and by diseases that otherwise affect children's skeletal growth and development. The age and maturity of an individual can be estimated from chronological age-related biological markers, such as teeth (Pinchi et al., 2018). Age can be estimated accurately from birth to 6 months of life from the timing of mineralization of the primary teeth crown. From 7 to 13 months of age, accurate estimates can be made from the stages of eruption (Tedeschi, Eckert and Tedeschi, 1977).

More recently, evidence on the influence of genetic factors on tooth development has increased. This new information questions the validity of global estimates on tooth eruption in estimating chronological age. Reaction to the possibility of genetic influences on tooth eruption profiles has been muted, however. Several authors have shown that tooth development in persons with Down syndrome – a genetic disorder – does not differ from that of the populations without the syndrome (Moraes et al., 2007; Diz et al., 2011; van der Linden et al., 2017; Pinchi et al., 2018). On the other hand, variations in dental age among regional populations (Liversidge 2003; 2008) and within regional and country populations have been observed (Rozzi, 2016). Pelsmaekers et al. (1997) suggested that variations in dental age are mainly the result of environmental effects during the prenatal, natal and immediate post-natal periods on genetic predisposition. Esan and Schepartz (2019) postulate that population differences in tooth eruption profiles are indicative of population differences in tooth maturation and the need for population-specific tooth-eruption profiles. However, Liversidge (2010; 2012) cautions against accepting observed differences as reflective of biological differences with genetic influence, as the differences are usually not more than one standard deviation.

Tooth development and maturation can be estimated from radiological assessments of stages of dental mineralization (Cunha et al., 2009) and/or by clinical evaluation of the time of tooth emergence (AlQahtani, Hector and Liversidge, 2010). Time of tooth emergence is a less valid method of assessing dental maturation than tooth mineralization because it is influenced by several factors, such as loss of the primary teeth, crowding, malnutrition, caries and orthodontic anomalies (Ogodescu et al., 2011). More credence is given to radiological assessment of teeth in the estimation of dental age. Such assessment compares radiographic dental development (mineralization) with published standards (an atlas) to arrive at an estimated dental age. Radiographic views that are used for age estimation are intraoral periapical radiographs, lateral oblique radiographs, cephalometric radiographs, panoramic radiographs, digital imaging and advanced imaging technologies (Panchbhai, 2011).

Dental maturity tables (atlases) include those by Schour and Massler (1941), based on the works of Logan and Kronfield (1933), Nolla (1960), Moorees, Fanning and Hunt (1963), and Nicodemo, de Moraes and Médici Filho (1974). More recently, we have had the London Atlas of Human Tooth Development and Eruption (AlQahtani, Hector and Liversidge, 2010) and the WITS Atlas (Esan and Schepartz, 2018b). The most popular atlas for assessing dental age and maturation in teenagers and adolescents is Demirjian's dental maturity scoring system (Demirjian, Goldstein and Tanner, 1973), which has many advantages over the Schour and Massler (1941) and Moorees, Fanning and Hunt (1963) atlases. The Demirjian system scores the seven permanent left mandibular teeth – exclusive of the third molar – using eight developmental stages. Each tooth is assessed for eight stages of mineralization (A to H), starting from cone-shaped calcifications of the upper portion of the crypt (stage A) to fully closed apices (stage H). The scoring system was first developed in 1973, based on a sample of French-Canadian children, and was revised in 1976 to include two additional methods based on the assessment of four teeth – one using both premolars and both molars and the other using both premolars, the second molar and the first incisor (Demirjian and Goldstein, 1976).

Population-specific comparisons on the accuracy of methods for estimating children's ages have yielded various results. The Demirjian method either underestimates (Ambarkova et al., 2014) or overestimates (Cunha et al., 2009; Cruz-Landeira et al., 2010; Galic et al., 2010; Nik-Hussein, Kee and Gan, 2011; Jayaraman et al., 2013; Ifesanya and Adeyemi, 2012; Yan et al., 2013; Ambarkova et al., 2014; Azzawi et al., 2016; Esan and Schepartz, 2018a; Kelmendi et al., 2018a; Markovic et al., 2019; Medina and Martínez, 2019) the dental age when compared with chronological age. Underestimation is greater for Asian than for European populations (Jayaraman et al., 2013) while overestimation may be greatest for African populations (Esan and Schepartz, 2018b). Differences have also been found for the same population with the two variations of the 1976 Demirjian dental maturity scoring system; one version overestimated and the other underestimated the age of the same population (Floods et al., 2011; El Meligy et al., 2019; Koruyucu and Seymen, 2019). Variations have also been found in the levels of overestimation by the different methods in the same population (Ambarkova et al., 2014; Akkaya, Yilanci and Göksülük , 2015) as in Saudi Arabia. While Al-Emran (2008) and Al-Dharrab et al. (2017) reported that dental age was overestimated, Nour et al. (2016) reported a slight underestimation.

In 2001, Willems et al. (2001) developed a dental maturity table for estimating dental age based on a modification of Demirjian's dental maturity scoring system and used the table for statistical analysis of dental age and maturation of Belgian children. More recently, Chaillet, Nystrom and Demirjian (2005) published international maturity curves for age estimation based on the ages of the first seven mandibular teeth among eight populations. Griffin and Malan (1987) and Solari and Abramovitch (2002) have made other modifications of Demirjian's dental maturity scoring system.

There are also reports on the over- and underestimation of age when using the methods of Willems et al. (El-Bakary, Hammad and Mohammed, 2010; Sehrawat and Singh, 2017; El Meligy et al., 2019; Markovic et al., 2019; Medina and Martínez, 2019) and Chaillet, Nystrom and Demirjian (Urzel and Bruzek, 2011; Galic et al., 2013). Studies that compared the method of Willems et al. with the method of Demirjian have found that the former method was a better age estimator for their population (Maber, Liversidge and Hector, 2006; Cameriere et al., 2008; Cruz-Landeira et al., 2010; Ambarkova et al., 2014; Akkaya, Yilanci and Göksülük, 2015). Gender differences in the accuracy of the five methods – Demirjian's method, using the premolars and both molars; Demirjian's method, using both premolars, the second molar and the first incisor; Demirjian's method, using the seven permanent teeth; the method of Willems et al.; and the method of Chaillet et al. – in the same population have also been reported (Kelmendi et al., 2018a).

The use of the London Atlas of Human Tooth Development for dental age estimation has been limited. Its use in Saudi Arabian populations showed a good match between chronological and dental age; and its findings correlated well with the outcome of Cameriere's third molar-maturity index (El Meligy et al., 2019). Cameriere's third molar-maturity index is another of the radiographic assessment indexes for adolescents and young adults (Galic et al., 2015; Zelic et al., 2016; Kelmendi et al., 2018b; Markovic et al., 2019). Other radiographic assessment indexes for adolescents and young adults are the coronal pulp-cavity index (Drusini, Toso and Ranzato, 1997) and the open apices index (Cameriere, Ferrante and Cingoloni, 2006; Rai and Anand, 2008). Also, data generated from radiographs can be analyzed statistically (multiple regression analysis) to determine the mean age and range at which 50% of the children are most likely to have a tooth emerged. Relevant statistical methods have been developed by Johanson (1971), Burns and Maples (1976), Maples (1978), Kashyap, Koteswar and Roa (1990), and Lucy et al. (1995).

After the age of 20 years, when third molar development is complete, age is usually estimated with biochemical markers (Ajmal, Mody and Kumar, 2001). One marker is the racemization of aspartic acid (Helfman and Bada, 1976; Mornstad, Pfeiffer and Teivens, 1994; Alkass et al., 2010), which is one of the three age-related changes that take place in proteins with age; the other two are oxidation and isomerization (Rastogi et al., 2017). High-performance liquid chromatography can be used to determine the ratio of dextrorotatory and levorotatory aspartic acid, which is an extremely reliable biomarker for age estimation (Fu et al., 1995; Helfman and Bada, 1976; Ohtani and Yamamoto, 2005).

Age can also be estimated from tooth structural changes. Li and Ji (1995) used the severity of tooth attrition for estimating age, whereas Kvaal and Solheim (1995) used cemental annulation lines. Age estimation using tooth color was reported by Solheim (1993). The Gustafson method (1950) is based on morphologic and histologic tooth changes – the amount of occlusal attrition, coronal secondary dentine formation, loss of periodontal attachment, cementum apposition at the root apex, and root resorption at the apex. The Dalitz method (1962-1963) is a modification of the Gustafson method; assessment was limited to the 12 anterior teeth, and cementum apposition at the root apex and root resorption at the apex were dropped from the assessment.

Radiographic assessments are useful also for estimating the dental age after 20 years. Assessments include evaluation of the reduction in size of the pulp chamber resulting from secondary dentine formation (Wedl and Friedrich, 2005); the pulp-tooth ratio (Kvaal and Solheim, 1995); and the ratio of the pulp canal to tooth volume (Vandevoort et al., 2004; Yang, Jacob and Willems, 2006).

In forensic pathology, root dentine transparency can be used for age estimation in adult human remains (Bang and Ramm, 1970). Although the third molar is useful for forensic age determination (Solari and Abramovitch, 2002), great variability in the development of the tooth (Mincer, Harris and Berryman, 1993; Gunst et al., 2003; Olze et al., 2005) makes it an unreliable tool for age estimation in living humans. The Harris and Nortje method (1984) and the Van Heerden system (1985) used the third molar for age estimation.

The dental age of children who have primary teeth can be estimated with a histologic assessment of the neonatal lines in the enamel and dentine of the primary teeth and first permanent molar; the lines reflect development that occurs during the transition from intrauterine to extrauterine life. Kraus and Jordan (1965) developed an atlas for estimating the age of the primary teeth. The incremental lines of Retzius, which are subjected to alterations by external factors, or the weight of developed dentine also can be used for estimating children's dental age (Prathap, 2017).

Tooth Emergence

The timing and sequence of tooth emergence are influenced by many factors including age (Haddad and Correa, 2005; Oziegbe et al., 2009), sex (Diamanti and Townsend, 2003; Lakshmappa, Guledgud and Patil, 2011; Kanagaratnam and Schluter, 2012), genetics (Hughes et al., 2007; Bockmann, Hughes and Townsend, 2010; Sharma, 2014), body weight (Correa-Faria et al., 2013; Kutesa et al., 2013; Verma et al., 2017; Al-Batayneh and Al-Rai, 2019; Haque et al., 2019; Mohebbi and Razeghi, 2019), height (Haddad and Correa, 2005; Oziegbe et al., 2009), ethnicity (Kanagaratnam and Schluter, 2012; Warren et al., 2016; Dawson et al., 2018), socioeconomic status (Bastos et al., 2007; Oziegbe et al., 2009); and prenatal (Pavicin et al., 2016; Zadzinska, Sitek and Rosset, 2016) and postnatal (Sajjadian et al., 2010; Ntani et al., 2015; Un Lam et al., 2016) variables. Growth hormone deficiencies can also cause delayed tooth development, with an impact that is more profound than skeletal growth delay in relation to chronological age (Sarnat et al., 1988; Vallejo-Bolaños et al., 1999).

Few studies have compared different population data on tooth emergence (Liversidge, 2003; 2008; Rozzi, 2016). Liversidge (2003) observed that some teeth erupted earlier in some African populations than in populations outside Africa. This observation was corroborated by Oziegbe, Esan and Oyedele (2014), who reported that the time of emergence of all the permanent teeth of a Nigerian population was earlier than that of children in the USA, Australia, Belgium, and Iran. However, Pakistani boys had an earlier mean age of emergence of the maxillary premolars and second molar than Nigerian boys. Rozzi (2016) observed that all teeth in the Baka Pygmy of Cameroon erupted earlier than in any other African population. The time of emergence of teeth in Lebanese children was delayed compared with that in Ghanaian, Canadian and Finnish children, although the first premolars in Lebanese children erupted earlier than those teeth in Finnish and Caucasian children (Debs and Sfeir, 2015). These observations are suggestive of population level differences and that there might not be regional homogeneity in the timing of tooth emergence.

Comparisons of population-based data can be limited by data availability. Of the 193 United Nations member states (United Nations, 2017), only 75 (38.9%) countries have data on tooth emergence accessible in the English literature. Our search was limited because we did not access materials on tooth emergence and tooth eruption written in languages that were not translated into English. We also did not have access to unpublished research documents, such as students' theses, which might have provided useful information. Africa is the continent with the least number of countries with data. Of the countries that had information on tooth eruption and emergence, 31 (16.1%) had information for both primary and permanent dentition, 10 (5.2%) for primary dentition, and 28 (14.5%) for only permanent dentition. The other six countries had information for some permanent and/or primary teeth. Other countries had data on tooth-emergence profiles of a few teeth in the primary and permanent dentition. Figure 1 is a map illustrating countries with data on tooth emergence. There are methodological differences in determining the age of tooth emergence for the various populations, and most of the studies did not analyze for determinants of chronological age – low birth weight, socioeconomic status, nutritional status, and others.

Developmental Dental Hard-tissue Anomalies

Data on developmental dental hard-tissue anomalies are derived mainly from prevalence studies. The anomalies can be categorized into anomalies of tooth shape, tooth size, tooth structure, tooth number and tooth position. Cross-sectional studies reveal significant variations in the anomalies among populations. These anomalies can be caused by environmental and genetic factors (Seymen and Folayan, 2019). Population-specific data on developmental dental hard-tissue anomalies are of epidemiological and anthropological importance. The inter-relatedness of many clinical dental features – normal and pathological – reflects the pleiotropic effects of genes during tooth development. The features provide insight into population dynamics and evolution and are helpful for the field of dental paleopathology (Lukacs, 2011).

Of the 193 United Nations member states, only 90 (46.6%) countries have accessible English-language publications on the epidemiology of

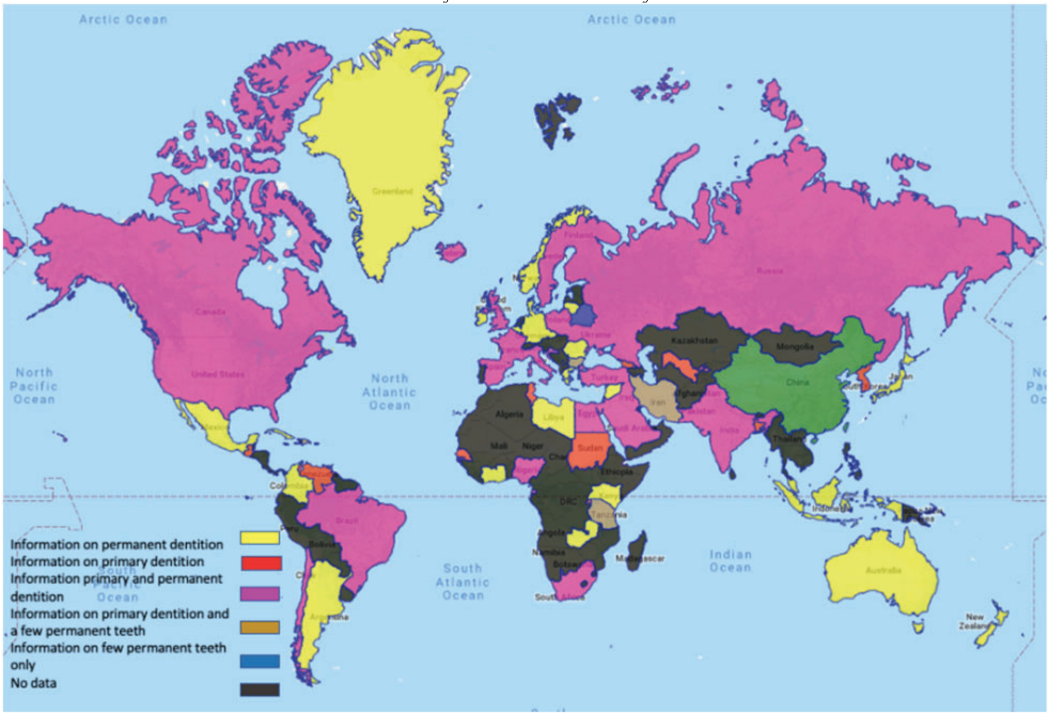

Figure 1: Map highlighting countries with and without data on the timing and sequence of teeth emergence (also available within colour centerfold)

developmental dental hard-tissue anomalies. Africa is the continent with the least number of countries with data. Most of the countries have data on developmental defects of the enamel, whereas fewer have data on anomalies of tooth number, shape, size, position and other tooth structures. Few countries have comprehensive data on developmental anomalies, and few have nationally representative data on developmental hard-tissue anomalies. Figure 2 is a map showing the countries that have data on these anomalies. Despite several years of research on this subject, significant gaps in country-specific information exist, which have implications for the development of a global map on the epidemiological profile of developmental dental hard-tissue anomalies.

Towards The Future: Growing the Research Frontiers

Most of the observed differences in dental and chronological ages for most populations are less than one year, which implies that their under- or overestimations do not connote inaccuracy (Staaf, Mörnstad and Welander, 1991). The observed difference in age estimation for an African population (Esan and Schepartz, 2018b) is, however, indicative of possible inaccuracies and the need for further study of racial and ethnic differences in tooth maturation.

Interest in the use of DNA markers – CpG sites – for estimating age is growing. The markers provide accuracies of ±3-4 years (Parson, 2018). Interest in the use of the epigenetic code is increasing because of recognition that significant change of global DNA methylation levels is associated with increasing age (Horvath at al., 2012). For the estimation of age by DNA methylation, large amounts of nucleic acids are required. Thus, targeted mRNA and CpG site assays were developed for the determination of age using small forensic samples (Parson, 2018). Eight mRNA markers (*NRCAM, ABLIM1, LRRN3, NELL2, NOG, CCR7, AK5* and *SLC16A10*) are down-regulated with age, and one (CFH) up-regulated gene is the best age-correlated marker. The age-prediction model based on all nine mRNA markers resulted in an overall R^2 of 0.523 (Zubakov et al., 2016). When used with assessments of dental age and skeletal age, the accuracy of age prediction improves significantly (Shi et al., 2018). Combinations of CpG markers were used to develop a quantitative age-prediction model, which gave a 0.96 correlation with the true chronological age, with an average error of 3.9 years (Hannum et al., 2013). Two salivary CpG markers can reveal 73% of the age variance and predict the chronological age with an accuracy of ±5.2 years (Bocklandt et al., 2011); *ELOVL2* – CpG markers have a Spearman correlation coefficient of 0.92 in blood (Garagnani et al., 2012).

Attempts to improve age prediction with the use of genetic markers from blood, saliva, semen and teeth are underway (Parson, 2018). Future research should focus on reducing the amount of DNA required for methylation analysis and on the standardization of protocols and analysis methods to facilitate DNA analysis for routine forensic use (Parson, 2018).

Evolving genetic and genomic research is not likely to reduce the need for and importance of dental tools in the estimation of age for forensic pathology. However, a more accurate estimation of age using teeth is needed. Teeth can provide enough material for DNA methylation, which may eventually result in diminished use of radiographic and histologic methods for estimating age and maturation, especially in children and adolescents. Dental age-estimation tools have been less well developed for primary teeth. The use of DNA methylation for age estimation has also been largely limited to European and Asian nations, with no data from Africa. The development of cheaper DNA methylation techniques is required to improve the generation of global data.

Exposure to environmental factors also etches its mark on the teeth in the form of hypoplasia. Hypoplasia is a poorly defined pathological entity that is difficult to diagnose. It is not a disease, but a condition that can be initiated by infections, malnutrition or syndromic disorders at the extreme end of normal variation. However, the point of departure from normal is poorly defined (Hillson, 2014). Estimations of the time and duration of the disturbances using atlases and clinical observations of the crown are only simplified approximations of tooth development (Hillson, 2014). Clinical detection of mild forms of disturbances of tooth mineralization is challenging, often leading to underestimation of the prevalence of the lesion (Hillson, 2014). Improved technology to accurately estimate the timing and duration of growth and development clinically is needed.

Limited efforts are being made to standardize, calibrate and evaluate procedures for estimating age and assessing hard dental-tissue anomalies. Quality assurance measures are not in place (Smith et al., 2009; Panchbhai, 2011). The use of scanning, micro- and nano-imaging techniques can help to standardize the estimation of dental age and increase the accuracy of the data generated, thereby facilitating comparisons of data (Townsend et al., 2012). More tools for the estimation

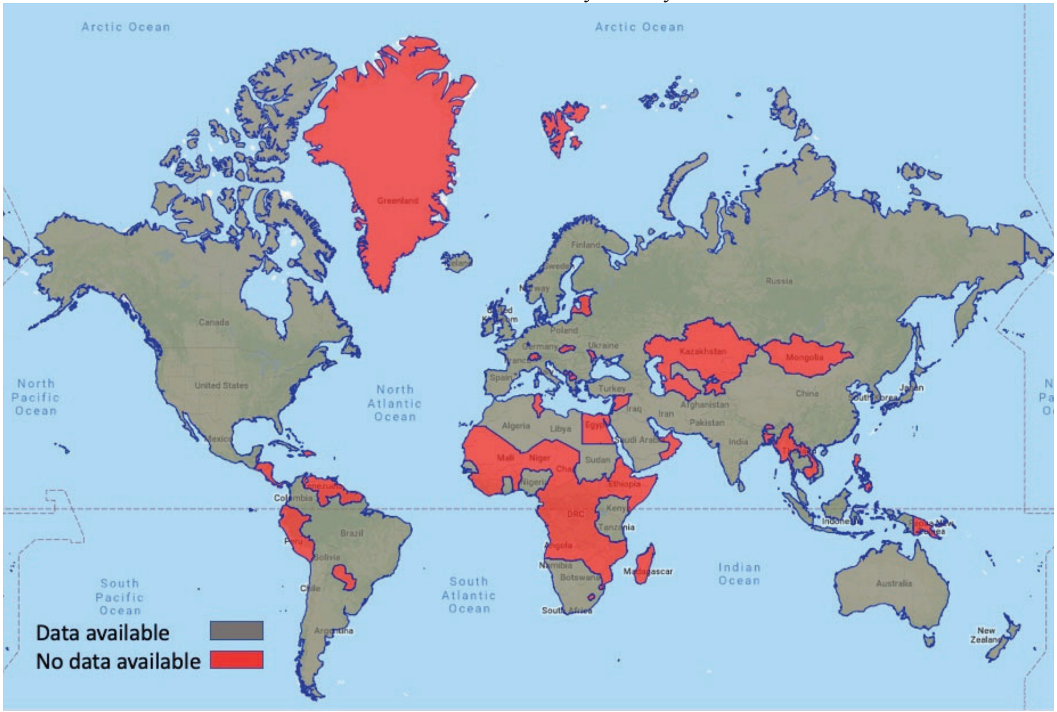

Figure 2: Map highlighting countries with and without published English data on developmental dental hard-tissue anomalies (also available within colour centerfold)

of dental age will be developed. In the absence of benchmarks for dental age estimation, the validity of reports on differences in the estimates and the assertions of possible genetic influences on tooth development cannot be verified.

Epidemiological profiles of tooth eruption, tooth emergence and developmental hard dental-tissue anomalies for individual countries will continue to be important for clinical pediatric dentistry and orthodontics. With globalization and mixed marriages increasing, dental hard-tissue profiles may change. Documentation of these changes is critical for an understanding of how human dentition evolves. National surveys on the prevalence of types of developmental dental anomalies are extremely limited. Where national surveys have been conducted, the scope of the anomalies studied has also been limited. There is a need to develop protocols for national epidemiological surveys on developmental dental hard-tissue anomalies; the protocols will facilitate the generation of comparable national data.

Finally, studies of developmental hard dental-tissue anomalies must evolve from the simple gathering of statistics to generating evidence for the prevention of lesions and their negative impact. Many of these lesions cause esthetic and functional problems, with associated poor quality of life (Vargas-Ferreira and Ardenghi, 2011). For children and adolescents, the lesions may lead to taunting, mockery and bullying, with significant psychological impact (Scheffel et al., 2014). In our research, we found no studies on how any developmental hard dental-tissue anomalies can be prevented. Research into the possible prediction of a child having developmental hard dental-tissue anomalies, and their prevention, will be most welcome. For gene-dependent anomalies, progress in gene editing (Cox, Platt and Zhang, 2015) may be a way forward.

Acknowledgement

Thanks to Mr Iniabasi Ukpong who helped to produce the maps.

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