

# About the Recent Chilean Immigration Phenomenon: A Scoping Review on Radiographic Methods for Dental Age Estimation in Children

Sobre el Reciente Fenómeno Migratorio Chileno: Una Revisión con Búsqueda Sistemática  
sobre Métodos Radiográficos para la Estimación de Edad Dental en Niños

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**SUMMARY:** The objective of this review was to identify original studies describing radiographic methods for dental age estimation applied in Chilean children, considering that it is a country with a long history of natural disasters and it has shown an unprecedented increase in the number of migrants in recent years, with significant percentages of individuals under 18 years of age. A scoping review was carried out following the methodology for the Joanna Briggs Institute scoping reviews and PRISMA guidelines. A specific search strategy was implemented in PubMed/Medline database, with complementary use of the Google Scholar website searching for full articles in English and Spanish. Five documents responded to the search objective, of which only 3 were published in refereed journals. Two documents focused their study on the maturation of upper and lower third molars, one on the maturation of the second and lower third molars, and two documents on the maturation of the seven mandibular teeth according to classical methodologies. The scarce existing literature, the almost absence of validated methods for the Chilean population, as well as the reported mass immigration phenomenon make a new and profound scientific research approach necessary for the application of updated methods.

**KEY WORDS:** Children; Chile; Dental age estimation; Forensic odontology; Immigration.

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## INTRODUCTION

Age estimation in forensic contexts is one of the procedures of greater attention in recent years due to the needs to identify victims of disasters, the increase in migratory phenomena, the intensity of crimes involving human trafficking or smuggling, or more specifically in children, the possibility that they are victims of crimes of sexual abuse (Franklin *et al.*, 2015; Sironi *et al.*, 2021). “Humanitarian forensic action”, term proposed by the International Committee of the Red Cross, is defined as “the application of forensic science to humanitarian activities”, which involves “a range of activities of that seek to alleviate

human suffering and protect the dignity of all victims” (Smitha *et al.*, 2019). Forensic dentistry has proven to play a fundamental role by offering information not only for the comparison of ante- and post-mortem data, but also for confirming the age, sex, stature, pathological conditions or habits based on well-studied dental morphological characters as traits for the reconstructive identification of the individual (Sengupta *et al.*, 2020). Specifically, in children and adolescents, dental age estimation involves the application of different methodologies where the radiographic evaluation of dental maturation is the basis of many techniques

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recommended for their reliability for both living and deceased individuals (Franklin *et al.*, 2015; Smitha *et al.*, 2019).

It has been conveniently reported that there is a need for population-specific data if reliability is sought in the application of a method for age estimation (Franklin *et al.*, 2015). Many standards in current use are based on analyses of other populations, sometimes formulated several generations ago or even on archaeological, military or cadaveric samples (Franklin *et al.*, 2015). It has been asserted that forensic dentists and oral health professionals can help prevent human rights violations through the application of best practice in human identification, and that human identification without complete post-mortem assessment can lead to delayed identifications thereby representing a violation of human rights and international humanitarian law (Smitha *et al.*, 2019). Considering that Chile, a South American country with a long history of natural disasters (Rojas-Torres *et al.*, 2019), has shown an unprecedented increase in the number of migrants in recent years with significant percentages of individuals under 18 years of age (Servicio Jesuita a Migrantes, 2019), the objective of this scoping review is to identify original studies describing radiographic methods for estimation dental age applied in Chilean children. The need to apply specific standards for this population as well as to update this information based on current populations to validate these methodologies are discussed.

## MATERIAL AND METHOD

A scoping review of the literature was carried out following the methodology for the Joanna Briggs Institute scoping reviews (Peters *et al.*, 2015) and PRISMA guidelines (Moher *et al.*, 2009). Scoping reviews have been referred as an appropriate methodology when seeking to answer broad research questions and to obtain an appreciation of the nature of the available evidence. Although scoping reviews do not assess the quality of the included studies (unlike systematic reviews), they can identify areas not yet covered in knowledge, define the scope of systematic reviews, or guide the development of focused research questions (Armstrong *et al.*, 2011). A specific search strategy "age estimation" AND ("child" OR "infant") AND ("dental" OR "teeth") AND ("Chile" OR "Chilean") was implemented in PubMed/Medline database, with complementary use of the Google Scholar website searching for full articles in English and Spanish, which were independently analyzed by two researchers between December 02, 2020 and December 15, 2020. Only original studies as primary sources were included, with no time limit, describing radiographic methods for estimating dental age whose samples partially or totally include Chilean living children and minors, that is, individuals up to 18 years of age residing in Chile. Studies on samples of individuals with pathological or nutritional deficient conditions or of historical or archaeological populations were excluded. The search identified 5 documents (Fig. 1), and the relevant data was extracted and

analyzed according to specific categories: information from the publication, characteristics of the sample, type of radiographic study performed and its outcomes.

## RESULTS

Table I provides an overview of the data in the reviewed documents. A total of 5 documents responded to the search objective, of which only 3 were published in refereed journals. The documents were published between 2007 and 2018. Two documents focused their study on the maturation of upper and lower third molars, one on the maturation of the second and lower third molars, and two

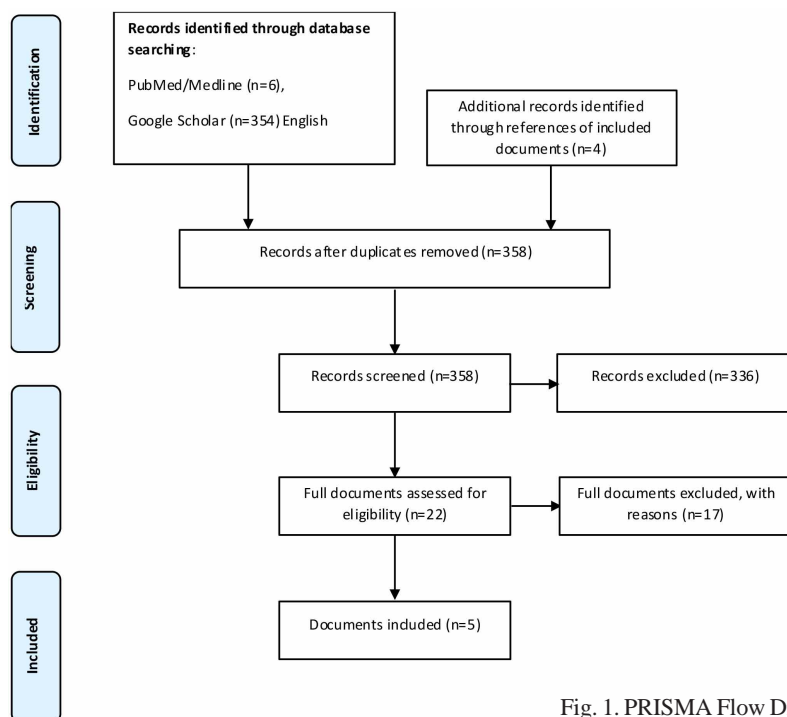


Fig. 1. PRISMA Flow Diagram for the scoping review process performed.

Table I. Documents identified in the review, discriminated variables and outcomes.

#	Reference	Type of publication	Sample	Type of radiographic study	Outcomes
1	Cameriere <i>et al.</i> (2018)	Article	OPGs from 822 individuals aged 11 to 22	Evaluation of dental maturity of the lower third and second molars according to Cameriere <i>et al.</i> methods (2006, 2008)	The study verified the reliability of the lower third molars in discriminating between minors and adults. The combination of these teeth with the lower second molars is evaluated to find cut-offs for fourteen and sixteen years.
2	Pinares Toledo (2015)	Master Thesis	OPGs from 1,236 individuals aged 13 to 26	Evaluation of dental maturity of upper and lower third molars according to Demirjian <i>et al.</i> method (1973)	The study verified the reliability of the third molars for age estimation only in individuals between the end of the second and the beginning of the third decade of life. There is a tendency towards early maturation.
3	Cadenas <i>et al.</i> (2014)	Article	OPGs from 363 individuals aged 5 to 15	Evaluation of dental maturity according to Demirjian <i>et al.</i> method (1973)	The study showed that the method tends to overestimate age.
4	Pérez Flores <i>et al.</i> (2010)	Article	OPGs from 159 individuals aged 3-14	Evaluation of dental maturity according to Demirjian <i>et al.</i> method (1973)	The range between chronological and dental age is similar, and the degree of correlation between both ages is nearly perfect.
5	Valdés Godoy (2007)	Undergraduate Thesis	OPGs from 216 individuals aged 14 to 22	Evaluation of dental maturity of upper and lower third molars according to Demirjian <i>et al.</i> method modified by Solari & Abramovitch (2002)	Variability of 1.20 years for women and 0.92 years for men is demonstrated. There are significant differences in the development of the upper and lower molars.

documents on the maturation of the seven mandibular teeth according to the classical methodology of Demirjian *et al.* (1973). In all cases, the radiographs used were orthopantomographs (OPGs), and the sample sizes were between 159 and 1,236 individuals, not coinciding in any case in the age ranges included. Only one document, a master thesis, exceeded a sample of 1,000 individuals (Pinares Toledo, 2015). The outcomes were reported in a very heterogeneous way, making their contrasts difficult.

## DISCUSSION

By August 2019, age estimation was by far the most cited topic in forensic dentistry, also proportionally composing the most cited source of original research (Sengupta *et al.*, 2020). An updated informal search of the term "dental age estimation" in the last 5 years reveals 173 results in PubMed, while in Google Scholar more than 1,800 results, which highlights the interest of the scientific community on this topic. Thus, the almost null presence of properly validated standards for estimating the dental age of Chileans under 18 years of age is surprising, taking into account the specific conditions of this country. Only 5 documents, 2 of them thesis (one undergraduate), only 1 article validating a current recommendation method (Cameriere *et al.*, 2018) but hardly focused on a specific age range to discriminate between minors and adults,

accounts for a necessary forensic research approach to this topic. It has already been reported that the Chilean population has a different ethnic characterization compared to the native population of other regions of the world, and a higher frequency of Amerindians, which reaches 80 % of the population (Rodríguez-Niklitschek *et al.*, 2015). This underlines the need to validate standards in this population to obtain population-specific dental maturation data that can be contrasted with those reported worldwide.

Chile is a country prone to natural disasters (Rojas-Torres *et al.*, 2019); Moreno-Pascual (2010), regarding the earthquake and tsunami that devastated the Chilean coasts in February 2010, reported 5 cases in which individuals between 2 and 17 years old had to be identified through estimates of their ages and radiographic analysis. In two of those cases, the ranges of the estimates spanned more than 3 years (Moreno-Pascual, 2010). Likewise, Chilean criminal legislation has become more complex for individuals in these age ranges: the implementation of the Law of Adolescent's Criminal Responsibility, which establishes a system of responsibility for adolescents between 14 and 18 years of age who violate criminal law, distinguishing two segments: 14 to 16 and 16 to 18 years for penalties (Ministerio de Justicia de Chile, 2011); the Chilean Penal Code sanctions the different types of sexual crimes against minors, establishing the range of 14 to 18 years of age for the figure of statutory rape to be configured (Fonseca *et al.*, 2018); marriage is granted at age 16 with the consent of a legal guardian; work

is not allowed before the age of 18 but from the age of 15 it can be accepted depending on the type of work (Cameriere *et al.*, 2018).

Although these circumstances have already been mentioned above, probably the most critical point is the very recent and unprecedented Chilean immigration phenomenon. By the end of 2019, 79.5 million people around the world have been forcibly displaced from their homes as a result of war, persecution, internal conflict or natural disasters (United Nations High Commissioner for Refugees, 2021a). Configuring the largest exodus in the region, by the end of 2019, about 4.5 million Venezuelans left their country, traveling mostly to other countries in Latin America and the Caribbean. Only 53 % have remained in neighboring countries; the rest have moved to other countries in the region, including Ecuador, Peru, Argentina, Panama and, of course, Chile (United Nations High Commissioner for Refugees, 2021a). According to the UNHCR, by mid-2020, Chile has received more than 450,000 migrants due to forced displacement, almost half of them in the last 2 years alone (United Nations High Commissioner for Refugees, 2021b). Almost half of these people are children below 18 years of age, which places them at special risk of abuse, neglect, violence, exploitation, and harmful practices (Franklin *et al.*, 2015).

However, the migratory phenomenon towards Chile does only include the forcibly displaced population: By December 2020, the total migrant population (including

professionals, students and volunteer migrants for labor issues), totals almost 1.5 million people, approximately 7.8 % of the total population of the country (Servicio Jesuita a Migrantes, 2022). Since the 1990s with the return of democracy and one of the largest regional economic growths, the migrant population increase has namely been from neighboring countries, (Peru, Argentina and Bolivia), to then diversify as of 2010 with the arrival of Colombians and Dominicans the early years; and Haitians and Venezuelans since 2014 (Servicio Jesuita a Migrantes, 2019). An unprecedented increase has been reported in Chile both in the number of migrants and in the percentage they represent in relation to the total population (Fig. 2), and approximately 15 % of these migrants are individuals under the age of 19 (Fig. 3) (Servicio Jesuita a Migrantes, 2019).

The development of human dentition follows a reliable and predictable sequence, which helps in both clinical and forensic settings. In children, the application of radiographic methodologies has proven to be very useful and reliable for estimating age, being considered more definitive and useful than other indicators (Fonseca *et al.*, 2015). However, the effect of applying “foreign standards” to estimate biological attributes has been suggested to revisit given the decrease in expected accuracy, according to Franklin *et al.* (2015), proportionally related to the increasing biological distance between the originally sampled population and the one to be evaluated. The authors assert that appropriate population-specific standards should be used on statistical bases, which will emerge from research carried

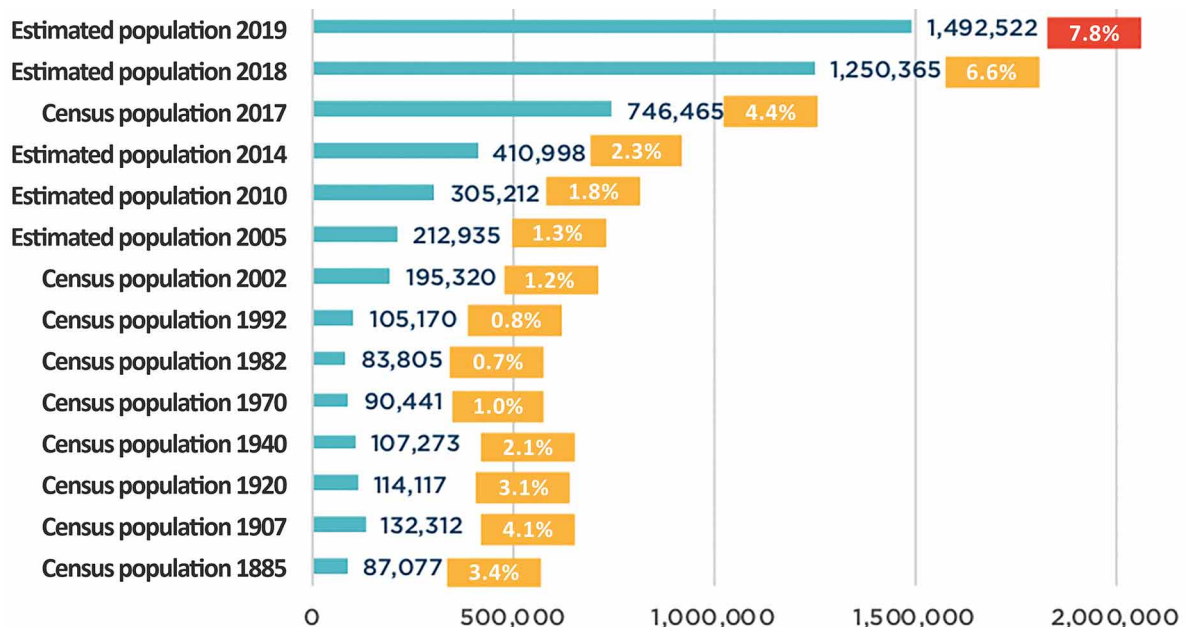


Fig. 2. Number of immigrants in Chile and percentage of immigrants with respect to the total number of residents in Chile between 1885 and 2019 (Adapted from Servicio Jesuita a Migrantes, 2019).

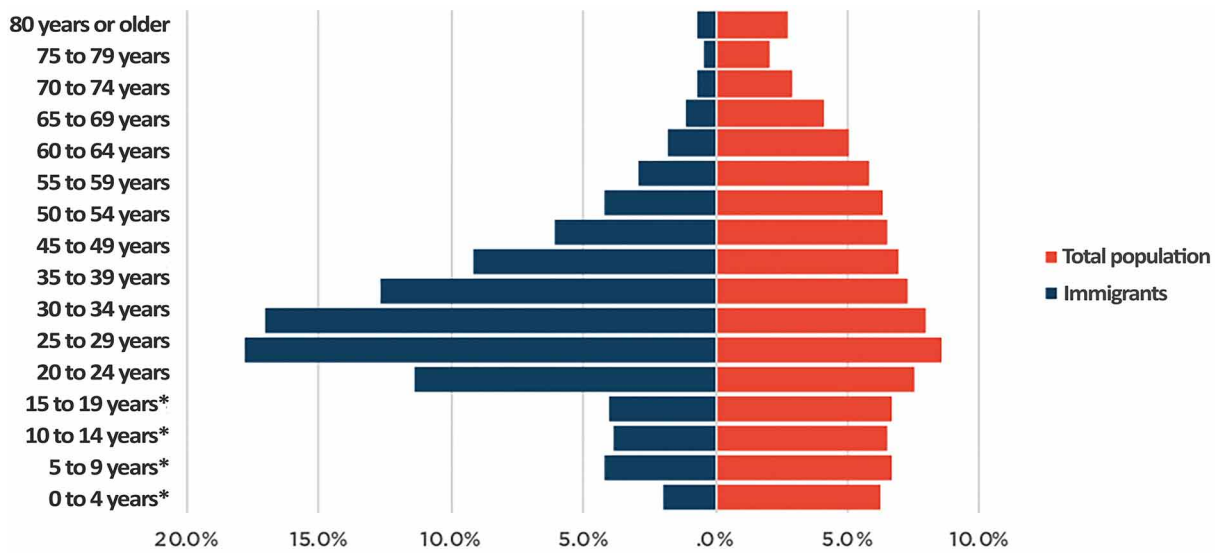


Fig. 3. Population pyramid of the immigrant population compared to the total resident population in Chile according to the 2019 approximation based on the 2017 Census (Adapted from Servicio Jesuita a Migrantes, 2019)

out by duly qualified entities, with an established background, and appropriate human and technological resources (Franklin *et al.*, 2015). Even though Latin Americans are usually considered as the same group, they do not constitute a homogeneous ethnic group as they present a great genetic, cultural, social, environmental, economic, educational and demographic diversity, with bases that unquestionably result in biological variations of great clinical, health and legal significance (Fonseca *et al.*, 2015).

Population specific standards are few for Latin Americans (Fonseca *et al.*, 2015; Iscan & Olivera, 2000), and more specifically in Chile in the field of age estimation, what little has been done has been focused on the study of historical or sub-actual populations or in archaeological contexts (Ericksen, 1997; Herrera & Retamal, 2017; González-Ramírez *et al.*, 2019). The situation of dental age estimation is not different, for which methodologies have been applied out of context or with small sample sizes (Cadenas *et al.*, 2014; Fonseca *et al.*, 2015). Recent Chilean history has revalued the role of forensic sciences for the identification of victims of human rights violations that occurred during the military dictatorship (1973-1990) (Quinn, 2014), for which the age estimation has seen the most current validations of different methodologies, but focused on individuals over the age of 18 (Retamal & Ubelaker, 2011; Aguilera-Muñoz *et al.*, 2019, 2020). This review agrees with what was previously reported by Fonseca *et al.* (2015) regarding the fact that there is a striking scarcity of dental age estimation studies in current Chilean and Latin American children, even more so considering the complex processes of genetic miscegenation, secular changes and

environment. For the authors, the best methodological alternative to apply will be the one that arises from comparative, cross-sectional and ethno-dependent studies that include the greatest number of variables (Fonseca *et al.*, 2015). Clearly the classic models are insufficient and decontextualized, and subject to large margins of overestimation or underestimation of dental age. Beyond what is reasonably acceptable as a range of estimation in a controlled scientific research environment, authorities and the courts may request these procedures in real cases and, like other expert reports, they must guarantee a well-functioning legal state, including clear statements on the age estimation reliability to allow the decision-maker to consider any doubt in a way that leads to a legal result that is as favorable as possible for the affected people (Schmeling *et al.*, 2016).

Age estimation is one of the forensic evaluations that can involve opinions of different experts, with different scientific backgrounds and different methods to answer the same question; according to Lidén & Dror (2021), this heterogeneity can have consequences that may affect communication between experts, so the reliability of their reports is both complex and multifaceted. The decision of the judicial or administrative authorities that a person be tried as an adult depends largely on the legal framework and a reliable expert report, for which the use and consideration of a normative approach that offers an appropriate structure of reasoning to support the decision-making process in forensic age estimation. Sironi *et al.* (2021) affirms that, although it does not protect against unfavorable results, this framework allows the decision-maker to make a coherent

decision, according to a structured and explicit thought process. Legal decision-makers, even though they may not have the necessary experience to make sound decisions, must identify and address scientifically complex issues, on which even scientific experts have not reached a consensus. The proposal to appoint more than one expert, not only from the same discipline but also from different disciplines to answer the same question, will incorporate a healthy "uncertainty" in the case, which will give the decision-maker a more feasible approach "to be aware of the possibility of expert disagreement and exercise the sort of damage control": to the extent that the disagreement can be reduced, the level of objectivity of the domain can be reflected (Lidén & Dror, 2021). Professional organizations and scientific societies have been encouraged to provide guidance to their members on medical, legal and ethical issues inherent in age estimation to help educate other stakeholders -for example, immigration judges- on common difficulties to use images to estimate age, as well as the most appropriate methodologies for it, their scope and limitations (Mishori, 2019).

## CONCLUSIONS

This review exposes the insufficient response of researchers to estimate dental age in children, the limited availability of validated methodologies on current Chilean populations and the consequent insufficient knowledge of the courts in this regard. The evident and unprecedented increases in migratory phenomena in a country prone to natural disasters such as Chile, as well as the potential challenges in all areas of children's rights, emphasize an imminent need for support from all participants system to resolve this situation.

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ACUÑA-MÉNDEZ, N.; ESPINOZA-SILVA, P. V.; RODRÍGUEZ-NIKLITSCHKE, C. & FONSECA, G. M. Sobre el reciente fenómeno migratorio chileno: Una revisión con búsqueda sistemática sobre métodos radiográficos para la estimación de edad dental en niños. *Int. J. Morphol.*, 40(3):650-656, 2022.

**RESUMEN:** El objetivo de esta revisión fue identificar estudios originales que describan métodos radiográficos para la estimación de la edad dental aplicados en niños chilenos, considerando que Chile es un país con una larga historia de desastres naturales y que ha mostrado un aumento sin precedentes en el número de inmigrantes en los últimos años, con porcentajes significativos de individuos menores de 18 años. Se llevó a cabo una revisión con búsqueda sistemática siguiendo la metodología del Instituto Joanna Briggs y las pautas PRISMA. Se implementó una estrategia de búsqueda específica en la base de datos PubMed/Medline, con uso complementario de Google Scholar, buscando artículos completos en inglés y español. Cinco documentos respondieron al

objetivo de búsqueda, de los cuales solo 3 fueron publicados en revistas arbitradas. Dos documentos centraron su estudio en la maduración de los terceros molares superiores e inferiores, uno en la maduración de los segundos y terceros molares inferiores y dos documentos en la maduración de los siete dientes mandibulares según metodologías clásicas. La escasa literatura existente, la casi ausencia de métodos validados para la población chilena, así como el fenómeno de inmigración masiva reportado, hacen necesario un nuevo y profundo enfoque de investigación científica para la aplicación de métodos actualizados.

**PALABRAS CLAVE:** Niños; Chile; Estimación de la edad dental; Odontología forense; Inmigración.

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