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Quantitative and Qualitative Approaches for Dental Age Assessment in Sub Adult Portuguese Population: European Regression Formula and Demirjian Stages

Kvantitativni i kvalitativni pristupi procjeni dentalne dobi u portugalskoj mlađoj populaciji: europska regresijska formula i Demirjianovi stadiji

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Abstract

Introduction: Over the last decade, the criminal justice system among the European countries deals with a new group of people, the undocumented people. In the criminal field, most of the suspected claimed to be under the minor legal age according to the type of crime. The government of each European country is committed to protecting the children and vulnerable people. There are serious safety concerns since adults falsely claim to be minors and legal systems oppose to such claims. In this study, we have used different age assessment methods and some of them without accuracy. **Objective:** To meet the general considerations we developed a study using the current dental age assessment methods. Hence, for the Portuguese population, this study aims to validate the European regression formula between the ages of 6 and 15 years of age; to estimate the cut-off point for the age of 12 years, and to compare the quantitative approach of European regression formula with Demirjian's qualitative approach for age estimation. **Materials and Methods:** 483 orthopantomograms were analysed using the European formula and Demirjian scoring stages. A new method, Model 2, was designed to better suit the Portuguese population. **Results:** The European formula: average age underestimation of 4.88 for the third quadrant and 4.04 months for the fourth quadrant; and a mean absolute error (MAE) of 10.93 and 10.68 months respectively. Demirjian method: average overestimation of 8.70 months, MAE of 12.85 months. In Model 2: MAE of 9.37 months for the third quadrant, and 9.28 months for the fourth quadrant. Both European formula and Demirjian method had an area under ROC curves results above 0.93. Discrepancy of sensitivity between methods for the specific cut-off point: 11.48. The results obtained in this study can be extrapolated to 87.33% of the Portuguese population. **Conclusions:** The European regression formula can be applied for the Portuguese population, and seems to be more accurate than Demirjian's methodology in this population. Nevertheless, both European regression formula and Demirjian method present similarly suitable results in the classification of 12 years of age, although there is a noticeable discrepancy favouring the European regression formula. The European Formula when applied for criminal age assessment, independently of population, is mandatory to indicate to the judicial institutions, the sensitivity of the results.

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Introduction

Forensic Dentistry is one of several branches within the Forensic Sciences. It is considered essential in multiple circumstances of expert practice (1). Age estimation is important when the chronological age of an unidentified living person is unknown and is required for defining legal and criminal responsibilities.

When discussing the Portuguese legal system, the legal age threshold for child liability when facing criminal charges and regarding child protection laws is 12 years of age. In the cases when legal documentation doesn't exist it is of utmost importance to properly estimate the child's age (2, 3).

From an international scope, proof of legal identity is of great relevance when considering the 2030 UN 16th Goal, so that children's rights can be protected and universal access to justice and social services can be enabled, highlighting once more the relevance of age estimation (4).

Age estimation is usually obtained by dental age assessment. This process is universally accepted as a reliable method of forensic application for a sub adult population (5-8).

Orthopantomograms are suitable for collecting information at the dental level, since it is possible to visualize all teeth, erupted and non-erupted in the oral cavity, with the least possible radiation and in a safe and non-invasive way. Since children's secondary sexual characteristics are often evaluated to give an estimate of their chronological age, which is an intrusive and potentially traumatic method, the use of panoramic images seems to be a more appropriate method for age estimation in children and adolescents(9).

The European regression formula, by Cameriere *et al.* (10), is one of the methods used to estimate age, in which the distance between the open apices is divided by the length of the tooth, thus obtaining the maturity index of seven teeth. The method proposed by Demirjian *et al. (11),* one of the most used scoring dental age estimation techniques (1), on the other hand, is applied by classifying teeth's mineralization rate in a panoramic image by means of an eight-stage system, ranging from A to H (or 0 when no mineralization is present), and converting these stages into numeric values used to calculate a maturity score.

The aims of the following study were to: validate European regression formula for the Portuguese population, between the ages of 6 and 15 years; estimate the cut-off point for the age of 12 years, as it is currently a relevant legal age threshold in the Portuguese criminal law; compare the quantitative approach of European regression formula (10) with Demirjian's (11) qualitative approach for age estimation currently used in the forensic practice, in order to contribute to age estimation at the international level, thus increasing biodiversity of the database by the insertion of additional biogeography.

Material and Methods

Sample

A total of 483 orthopantomograms (OPGs) were collected from Portuguese children aged between 6 and 15 years. The sex and age distribution of the OPG can be observed in Table 1. The samples were randomly taken from the radio-

Uvod

Forenzička stomatologija jedna je od nekoliko grana unutar forenzičkih znanosti. Smatra se bitnom u višestrukim okolnostima vještačenja (1). Procjena dobi važna je kada je nepoznata kronološka dob neidentificirane žive osobe i potrebna je za definiranje zakonske i kaznene odgovornosti.

Kada govorimo o portugalskome pravnome sustavu, zakonski dobni prag za odgovornost djeteta kada se suočava s kaznenim optužbama i u vezi sa zakonima o zaštiti djece, jest 12 godina. U slučaju da zakonska dokumentacija ne postoji, iznimno je važno pravilno procijeniti dob djeteta (2, 3).

Na međunarodnoj razini veoma je važan dokaz pravnoga identiteta kada se razmatra 16. cilj UN-a za 2030., kako bi se mogla zaštititi prava djece i omogućio univerzalni pristup pravdi i socijalnim uslugama, te se još jedanput ističe važnost procjene dobi (4).

Procjena dobi obično se dobiva procjenom dentalne dobi. Taj je postupak univerzalno prihvaćen kao pouzdana metoda forenzičke primjene za mlađu odraslu populaciju (5 – 8).

Ortopantomogrami su pogodni za prikupljanje podataka na razini zuba jer se mogu vizualizirati svi – i iznikli i neiznikli u usnoj šupljini – uz najmanje moguće zračenje i to sigurno i neinvazivno. Budući da se često procjenjuju sekundarna spolna obilježja djece kako bi se dobila procjena njihove kronološke dobi, što je intruzivna i potencijalno traumatična metoda, korištenje panoramskih slika čini se prikladnijom metodom za procjenu dobi djece i adolescenata (9).

Europska regresijska formula Camerierea i suradnika (10) jedna je od metoda za procjenu dobi u kojoj se udaljenost između otvorenih vrhova zuba dijeli s njihovom dužinom, čime se dobiva indeks zrelosti za sedam zuba. Metoda koju su predložili Demirjian i suradnici (11) jedna je od najčešće korištenih tehnika bodovanja za procjenu starosti zuba (1), s druge strane primjenjuje se klasificiranjem stupnja mineralizacije zuba na panoramskoj slici s pomoću sustava od osam stupnjeva u rasponu od A do H (ili 0 kada nema mineralizacije) i pretvaranjem tih faza u numeričke vrijednosti koje se koriste za izračunavanje ocjene zrelosti.

Ciljevi studije bili su potvrditi europsku regresijsku formulu za portugalsku populaciju u dobi između 6 i 15 godina, procijeniti graničnu točku za dob od 12 godina zato što je to trenutačno relevantan zakonski dobni prag u portugalskome kaznenome pravu, usporediti kvantitativni pristup europske regresijske formule (10) s Demirjianovim (11) kvalitativnim pristupom za procjenu dobi koji se trenutačno primjenjuje u forenzičkoj praksi kako bi se pridonijelo procjeni dobi na međunarodnoj razini, čime se povećava bioraznolikost baze podataka umetanjem dodatne biogeografije.

Materijal i metode

Uzorak

Ukupno su pregledana 483 ortopantomograma (OPG) portugalske djece u dobi između 6 i 15 godina. Spolna i dobna distribucija OPG-ova može se vidjeti u tablici 1. Uzorci su nasumično uzeti iz baze podataka radiografskih snimki Sto-

Table 1 Sex and age distribution
Tablica 1. Distribucija prema spolu i dobi

Age • Dob	Female • Žensko	Male • Muško	Total • Ukupno
6	5	31	36
7	24	43	67
8	38	43	81
9	29	34	63
10	23	36	59
11	18	37	55
12	23	23	46
13	14	20	34
14	8	16	24
15	6	12	18
Total • Ukupno	188	295	483

graph database of the Stomatology Department at the Santa Maria Hospital located in Lisbon, Portugal. The patients' OPGs were retrieved from the Lisbon North Hospital Center.

Selection criteria for the OPG were healthy individuals of Portuguese origin, chronological age of the individuals aged between 6 and 15 years, the presence of all seven permanent teeth in the third quadrant, absence of caries, restorations, root canal treatments or any form, position or shape alteration, congenital or otherwise, in any of the relevant teeth, and absence of overlapping images of teeth and of orthodontic treatment on the lower jaw. Any OPG found to be of very poor quality, for example, out of focus, blurred or with too high or low contrast, was excluded from the study. The fourth quadrant would have been analyzed as well if the aforementioned criteria had matched those of the third quadrant. Thus, while the third quadrant of all 483 OPGs were analyzed, only 440 OPGs presented fourth quadrants that matched the required criteria.

The subject's sex, date of birth, and date of the OPG were recorded. The chronological age for each subject was determined by subtracting the date of birth from the date of the OPG.

The study was performed in accordance with the ethical standards specified by the Health Ethics Committee of the Faculty of Dental Medicine, University of Lisbon, under the registration numbers 911103 and 911104.

Measurements and Scores

The selected OPGs were analyzed in accordance with two distinct methods, the first of which was proposed by Demirjian *et al.* (11) and the second by Cameriere *et al.* (10).

Demirjian's method falls back on the staging from A to H (8 stages) of the observed teeth, based on a visual guide. The first 4 (A–D) refer to the formation of the crown. The following stages (E–H) range from the beginning of root formation to apical closure (11). The score of each stage is allocated, and the sum of the scores provides an evaluation of the subject's dental maturity. The dental maturity score can be converted into the dental age using available tables. Subsequently, the percentile curves from the original study are allocated, and the sum of the scores provides an evaluation of the subject's dental maturity. A difference between the dental and chronological age of a subject indicates an advancement or delay in dental maturity (11).

matološkog odjela bolnice Santa Maria u Lisabonu, Portugal. OPG-ovi pacijenata dobiveni su od lisabonskoga Sjevernoga bolničkog centra.

Kriteriji odabira za OPG bili su zdravi pojedinci portugalskoga podrijetla, kronološka dob između 6 i 15 godina, svih sedam trajnih zuba u trećem kvadrantu, zatim odsutnost karijesa, restauracija, liječenja korijenskih kanala ili bilo kojeg oblika, položaj ili promjena oblika prirođena ili drukčija u bilo kojemu od relevantnih zuba te odsutnost preklapajućih slika zuba i ortodontskoga tretmana na donjoj čeljusti. Bio je isključen svaki OPG za koji se ustanovilo da je vrlo loše kvalitete, na primjer, ako je bio izvan fokusa, zamućen ili s previsokim ili niskim kontrastom. Četvrti kvadrant također bi bio analiziran da su navedeni kriteriji odgovarali onima iz trećeg kvadranta. Dakle, analiziran je treći kvadrant 483 OPG-a, a njih samo 440 imalo je četvrte kvadrante koji su odgovarali traženim kriterijima.

Zabilježeni su spol subjekta, datum rođenja i datum OPG-a. Kronološka dob za svakog ispitanika određena je oduzimanjem datuma rođenja od datuma OPG-a.

Istraživanje je provedeno u skladu s etičkim standardima Povjerenstva za zdravstvenu etiku Fakulteta dentalne medicine Sveučilišta u Lisabonu pod registracijskim brojevima 911103 i 911104.

Mjerenja i bodovi

Odabrani OPG-ovi analizirani su u skladu s dvjema različitim metodama od kojih su prvu predložili Demirjian i suradnici (11), a drugu Cameriere i suradnici (10).

Demirjianova metoda oslanja se na postavljanje promatranih zuba od A do H (8 stupnjeva) na temelju vizualnog vodiča. Prva četiri (A – D) odnose se na formiranje krune. Sljedeće faze (E –H) kreću se od početka formiranja korijena do zatvaranja vrha (11). Dodjeljuje se rezultat svake faze, a zbroj rezultata daje procjenu dentalne zrelosti ispitanika. Rezultat dentalne zrelosti može se s pomoću dostupnih tablica pretvoriti u dentalnu dob. Nakon toga dodjeljuju se krivulje percentila iz izvorne studije, a zbroj rezultata daje procjenu dentalne zrelosti ispitanika. Razlika između dentalne i kronološke dobi upućuje na napredovanje ili kašnjenje u dentalnoj zrelosti (11).

The method by Cameriere *et al.* (12) requires the measurement of the distance between the inner walls of open apices (A) divided by the length (L) of each developing permanent tooth, in the case of a single root tooth, or the sum of the width of open apices divided by the length of a multi root tooth, subsequently including these values in a linear regression. For this study, the applied linear regression formula was the one described in the 2007 study by Cameriere *et al.* (10) which contains different coefficients from the original, and will henceforth be referred to as the European regression formula. Hence, dental age was computed according to the European regression formula (10):

$$Age = 8.387 + 0.282\ g - 1.692\ x_5 + 0.835\ N_0 - 0.116\ s - 0.139\ s\ N_0,$$

where g = 1 for boys and g = 0 for girls, s is the sum of the normalized widths of apices of the seven left permanent developing mandibular teeth ($x_i = A_i/L_i$, i = 1, …,7), N_0 is the number of teeth with completed root development and x_5 is the normalized measurement of the second premolar (10,12-14).

The OPGs were saved in a JPEG image format from the SECTRA® imaging software, by SECTRA AB, Sweden, and measured using the *ImageJ*® software program (Image Processing and Analysis in Java), developed by the National Institutes of Health, USA. As the program requires a scale to convert the measurements from pixels to millimeters, for this study the scale used was the one that was already present on the images themselves, created by the radiographic equipment of the Stomatology Service. The images were scaled at 300% to allow for the measuring of the teeth.

Statistical Analysis

To quantify the intra- and inter-observer agreement, 50 OPG were randomly selected from the sample 3 months after the initial scoring process, onto which the intra-class correlation coefficient (ICC) was applied. For the evaluation of the Demirjian (11) stages, the weighted Cohen's kappa was applied. Spearman and Pearson correlations were used to assess the relationship between variables and chronological age. Linear regression was applied using the same variables as in the European regression formula (10), to better fit the Portuguese population. Kolmogorov-Smirnov and Shapiro-Wilk tests were applied to test normality. Wilcoxon and Mann-Whitney tests were performed to compare estimation errors between models.

The cut-off point was established for the age of 12 years by the use of the European regression formula (10) and Demirjian's (11) staging by the application of binary logistic regression. The sensitivity, specificity, Youden's index (sensitivity + specificity - 1), correct classification (or accuracy), positive (PPV) and negative (NPV) predictive values and positive (LR+) and negative (LR-) likelihood ratios were computed to assess the reliability of the performed classification. Finally, post-test probabilities (Bayes PTP) were calculated using Bayes' theorem (15), to allow the extrapolation of the results to the Portuguese population, through the 2019 demographic data extracted from the data base of the

Metoda Camerierea i suradnika (12) zahtijeva mjerenje udaljenosti između unutarnjih stijenki otvorenih vrhova (A) podijeljeno s duljinom (L) svakoga stalnoga zuba u razvoju u slučaju zuba s jednim korijenom, ili zbrojem širine otvorenih vrhova podijeljeno s duljinom višekorijenskoga zuba i te se vrijednosti naknadno uključuju u linearnu regresiju. U ovoj studiji primijenjena je formula linearne regresije koju su 2007. opisali Cameriere o suradnici (10), a sadržava koeficijente različite od izvornika te će se ubuduće nazivati europska regresijska formula. Zato je dentalna dob izračunata prema europskoj regresijskoj formuli (10):

$$dob = 8{,}387 + 0{,}282\ g - 1{,}692\ x5 + 0{,}835\ N0 - 0{,}116\ s - 0{,}139\ s\ N0,$$

pri čemu je g = 1 za dječake i g = 0 za djevojčice, **s** je zbroj normaliziranih širina vrhova sedam lijevih stalnih zuba mandibule u razvoju (xi = Ai/Li, i = 1, …,7), N0 je broj zuba sa završenim razvojem korijena i x5 je normalizirana mjera drugoga pretkutnjaka (10,12 – 14).

OPG-ovi su spremljeni u JPEG formatu slike iz SECTRA® softvera za snimanje tvrtke SECTRA AB iz Švedske i izmjereni s pomoću softverskoga programa ImageJ® (Obrada i analiza slike u Javi) koji je razvio Nacionalni institut za zdravlje SAD-a. Budući da program zahtijeva ljestvicu za pretvorbu mjera iz piksela u milimetre, za ovu studiju korištena je ljestvica koja je već prisutna na samim slikama izrađenima radiografskom opremom Stomatološke službe. Slike su skalirane na 300 % da bi se omogućilo mjerenje zuba.

Statistička analiza

Da bi se kvantificirao sporazum unutar promatrača i među promatračima, 50 OPG-ova nasumično je odabrano iz uzorka tri mjeseca poslije početnoga procesa bodovanja te je na njih primijenjen koeficijent korelacije unutar klase (ICC). Za procjenu Demirjianovih (11) stupnjeva primijenjena je ponderirana Cohenova kappa. Za procjenu odnosa između varijabli i kronološke dobi korištene su Spearmanove i Pearsonove korelacije. Linearna regresija primijenjena je korištenjem istih varijabli kao u europskoj regresijskoj formuli (10) kako bi bolje odgovarala portugalskoj populaciji. Za ispitivanje normalnosti primijenjeni su Kolmogorov-Smirnovljev i Shapiro-Wilkov test. Provedeni su Wilcoxonov i Mann-Whitneyjev test za usporedbu pogrešaka u procjeni između modela.

Granična točka utvrđena je za dob od 12 godina primjenom europske regresijske formule (10) i Demirjianova (11) stupnja primjenom binarne logističke regresije. Osjetljivost, specifičnost, Youdenov indeks (osjetljivost + specifičnost – 1), ispravna klasifikacija (ili točnost), pozitivne (PPV) i negativne (NPV) prediktivne vrijednosti te pozitivni (LR+) i negativni (LR-) omjeri vjerojatnosti izračunati su za procjenu pouzdanost obavljene klasifikacije. Konačno, vjerojatnosti nakon testiranja (Bayesov PTP) izračunate su korištenjem Bayesova teorema (15) da bi se omogućila ekstrapolacija rezultata na portugalsko stanovništvo na temelju demografskih

National Institute of Statistics, Portugal (https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_main). All data analysis and tests were executed using the IBM® SPSS® Statistics (Statistical Package for the Social Sciences by IBM Technology Company), version 27.

Results

The intra-observer validation through ICC for the European regression formula (10) varied between 0.603 and 0.996 for observer 1 and between 0.689 and 0.999 for observer 2. As for the inter-observer validation, this one varies between 0.523 and 0.996. Weighted Cohen's kappa for intra-observer validation of Demirjian's (11) method varies between 0.919 and 1.000. In terms of inter-observer validation, kappa varies between 0.650 and 0.968.

Correlation coefficients, where absolute values above 0.700 are considered of great significance, showed: in the third quadrant, the most significant Pearson's correlation coefficients are associated with the variables N_0 (0.858), s (-0.829), x_7 (-0.813), x_4 (- 0.807) and x_3 (-0.763); in the fourth quadrant, they are associated with variables N_0 (0.850), s (-0.765), x_7 (-0.749), x_4 (-0.739) and x_5 (-0.722). Demirjian's (11) variable in the third quadrant obtained a correlation with the children's age both through Spearman's and Pearson's methods, of 0.880 and 0.748 respectively.

Age was firstly estimated by applying the European regression formula (10) with the coefficients determined by Cameriere *et al.* (10), (Model 1). An average underestimation of 4.88 and 4.04 months, in the third and fourth quadrants, respectively, can be observed, with the mean absolute error of 10.93 months in the third quadrant and 10.68 months in the fourth.

The second estimation (Model 2) was performed by applying linear regression to our sample, using the same explanatory variables. The adjusted correlation coefficient (adjusted R^2) value was 0.809 for the third quadrant and 0.816 for the fourth, and the standard error of the estimation 12.82 and 12.83 months, respectively. The obtained equation for the third quadrant was

$$\text{Age} = 116.725 + 4.290\, g - 10.726\, x_5 + 8.000\, N_0 - 13.981\, s - 3.229\, s\, N_0,$$

and for the fourth quadrant it was

$$\text{Age} = 122.186 + 5.403\, g - 15.677\, x_5 + 6.591\, N_0 - 17.434\, s - 3.848\, s\, N_0.$$

This model was found to have an absolute mean estimation error of 9.37 months in the third quadrant and 9.28 months in fourth (Table 2).

Taking into account the proximity of the values obtained in the third and fourth quadrants, alongside with Wilcoxon test (p-value equal to 0.174 in Model 1 and equal to 0.390 in Model 2), it seems there are not any statistically significant differences between the estimates obtained using the third and fourth quadrants in both models. Thus, the analysis will be restricted to the third quadrant.

The last estimation model (Model 3) was the applica-

podataka iz 2019. dobivenih iz baze podataka portugalskoga Državnoga instituta za statistiku (https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_main). Sve analize podataka i testovi obavljeni su u programu IBM® SPSS® Statistics (Statistical Package for the Social Sciences by IBM Technology Company), verzija 27.

Rezultati

Provjera valjanosti unutar promatrača putem ICC-a za europsku regresijsku formulu (10) varirala je između 0,603 i 0,996 za promatrača 1 i između 0,689 i 0,999 za promatrača 2. Kada je riječ o provjeri valjanosti između promatrača, ona varira između 0,523 i 0,996. Ponderirana Cohenova kappa za intrapromatračku provjeru valjanosti Demirjianove (11) metode varira između 0,919 i 1,000. Kada je riječ o provjeri među promatračima, kappa varira između 0,650 i 0,968.

Koeficijenti korelacije, pri čemu se apsolutne vrijednosti iznad 0,700 smatraju velikima, pokazali su sljedeće: u trećem kvadrantu najznačajniji Pearsonovi koeficijenti korelacije povezani su s varijablama N0 (0,858), s (-0,829), x 7 (-0,813), x4 (- 0,807) i x 3 (-0,763); u četvrtom kvadrantu pridružene su varijablama N0 (0,850), s (-0,765), x 7 (-0,749), x 4 (-0,739) i x 5 (-0,722). Demirjianova (11) varijabla u trećem kvadrantu dobila je korelaciju s dobi djece i Spearmanovom i Pearsonovom metodom, od 0,880, odnosno 0,748.

Dob je najprije procijenjena primjenom europske regresijske formule (10) s koeficijentima koje su odredili Cameriere i suradnici (10) (model 1). Može se uočiti prosječno podcjenjivanje od 4,88, odnosno 4,04 mjeseca u trećem i četvrtom kvadrantu sa srednjom apsolutnom pogreškom od 10,93 mjeseca u trećem kvadrantu i 10,68 mjeseci u četvrtome.

Druga procjena (model 2) provedena je primjenom linearne regresije na naš uzorak, koristeći se istim eksplanatornim varijablama. Vrijednost prilagođenoga koeficijenta korelacije (prilagođeni R2) bila je 0,809 za treći kvadrant i 0,816 za četvrti, a standardna pogreška procjene 12,82, odnosno 12,83 mjeseca. Dobivena jednadžba za treći kvadrant bila je:

dob = 116,725 + 4,290 g – 10,726 x5 + 8,000 N0 – 13,981 s – 3,229 s N0,

a za četvrti kvadrant bila je

dob = 122,186 + 5,403 g – 15,677 x5 + 6,591 N0 – 17,434 s –3,848 s N0.

Utvrđeno je da taj model ima apsolutnu pogrešku u procjeni srednje vrijednosti od 9,37 mjeseci u trećem kvadrantu i 9,28 mjeseci u četvrtome (tablica 2.).

Uzimajući u obzir blizinu vrijednosti dobivenih u trećem i četvrtom kvadrantu, uz Wilcoxonov test (p-vrijednost jednaka 0,174 u modelu 1 i jednaka 0,390 u modelu 2), čini se da nema statistički značajnih razlika između procjene dobivene korištenjem trećega i četvrtoga kvadranta u oba modela. Zato će analiza biti ograničena na treći kvadrant.

Posljednji model procjene (model 3) bila je primjena Demirjianove (11) metodologije. Tu se uočava precijenjenost od gotovo 9 mjeseci (u prosjeku) te srednja apsolutna pogreška od 12,85 mjeseci (tablica 2.).

Table 2 Comparison of estimation and absolute estimation errors of different estimation models
Tablica 2. Usporedba pogrešaka u procjeni i apsolutne pogreške različitih modela procjene

	Estimation Error • Pogreška procjene					Absolute Estimation Error • Apsolutna pogreška procjene				
	Model 1		Model 2		Model 3	Model 1		Model 2		Model 3
	3Q	4Q	3Q	4Q	3Q	3Q	4Q	3Q	4Q	3Q
Minimum	-78.23	-79.34	-57.66	-66.07	-72.94	0.04	0.07	0.01	0.00	0.00
Percentile 25	-12.67	-11.46	-7.54	-7.82	0.40	4.32	4.07	3.10	3.45	5.00
Median	-4.46	-3.71	-0.47	-0.03	8.60	8.87	8.58	7.47	7.23	10.14
Percentile 75	4.25	4.36	7.43	6.99	17.20	15.34	14.27	13.30	12.41	17.80
Maximum	49.67	60.33	74.28	76.90	70.00	78.23	79.34	74.28	76.90	72.94
Mean	-4.88	-4.04	0.00	0.00	8.70	10.93	10.68	9.37	9.28	12.85
Standard Deviation	13.69	14.08	12.82	12.83	14.60	9.57	10.02	8.73	8.85	11.12

3Q and 4Q denotes the third and fourth quadrants. • 3Q i 4Q – treći i četvrti kvadrant
Model 1 - European regression formula • europska regresijska formula; Model 2 - Portuguese regression • portugalska regresija; Model 3 - Demirjian's methodology • Demirjianova metodologija

tion of Demirjian's (11) methodology. An overestimation of almost 9 months (on average), and a mean absolute error amounting to 12.85 months (Table 2), are observed here.

The Mann-Whitney test (p-value equal to 0.909 in Model 1; 0.836 in Model 2 and 0.810 in Model 3) did not reveal differences in the estimation errors between sexes.

When comparing the three models, the null average error of Model 2 is highlighted, while Model 1 is underestimated by almost 5 months and Model 3 is overestimated by almost 9 months (on average). The mean absolute error has the highest value in Model 3 (12.85 months), followed by Model 1 (10.93 months) and Model 2 (9.37 months).

Upon using the Wilcoxon test for paired samples, all models revealed significant differences (p-value equal to zero in all comparisons). Moreover, the Wilcoxon test for paired samples was also applied to compare the estimates of the 3 models with chronological age: Model 2 (p-value = 0.846) did not reveal any significant differences; Model 1 (p-value = 0) and Model 3 (p-value = 0) revealed a number of statistically significant differences.

Using the s variable from the European regression formula (10) and Demirjian's (11) method, a cut-off point was established for the age of 12 years (Table 3). From the Europe-

Mann-Whitneyjev test (p-vrijednost jednaka 0,909 u modelu 1; 0,836 u modelu 2 i 0,810 u modelu 3) nije otkrio razlike u pogreškama procjene između spolova.

Pri usporedbi triju modela istaknuta je nulta prosječna pogreška modela 2, dok je model 1 podcijenjen za gotovo 5 mjeseci, a model 3 precijenjen za gotovo 9 mjeseci (u prosjeku). Srednja apsolutna pogreška ima najveću vrijednost u modelu 3 (12,85 mjeseci), zatim u modelu 1 (10,93 mjeseci) i modelu 2 (9,37 mjeseci).

Nakon korištenja Wilcoxonova testa za uparene uzorke, svi su modeli pokazali značajne razlike (p-vrijednost jednaka nuli u svim usporedbama). Štoviše, taj je test također primijenjen za usporedbu procjena triju modela s kronološkom dobi: model 2 (p-vrijednost = 0,846) nije otkrio značajne razlike; model 1 (p-vrijednost = 0) i model 3 (p-vrijednost = 0) otkrili su niz statistički značajnih razlika.

S pomoću varijable s iz europske regresijske formule (10) i Demirjianove (11) metode utvrđena je granična točka za dob od 12 godina (tablica 3). Iz europske regresijske formule (10) korištena je samo varijabla s jer su rezultati bili praktički jednaki onima koji bi se dobili procjenom dobi. Nije ovisio o koeficijentima procijenjenima linearnom regresijom (koja je primjenom modela 1 i 2 dobila različite procjene).

Table 3 Results for the age of 12 in the Portuguese population
Tablica 3 Rezultati za dob od 12 godina u portugalskoj populaciji

Age: 12 years • Dob: 12 godina	European regression formula • Europska regresijska formula	Demirjian's method • Demirjianova metoda
Cut-off value	0.28	96.2
Sensitivity	81.97%	70.49%
Specificity	91.41%	91.97%
Youden's index	73.38%	62.46%
Accuracy	89.03%	86.54%
PPV	76.34%	74.78%
NPV	93.75%	90.22%
LR+	9.55	8.78
LR-	0.20	0.32
Bayes PTP	87.33%	86.37%
AUC	0.948	0.932

PPV - positive predictive value • pozitivna prediktivna vrijednost, NPV - negative predictive value • negativna prediktivna vrijednost, LR+ - positive likelihood ratio • pozitivni omjer vjerojatnosti, LR- - positive likelihood ratio • pozitivni omjer vjerojatnosti, Bayes PTP - Bayes post-test probabilities • Bayesove posttestne vjerojatnosti, AUC - area under the ROC curve • površina ispod ROC krivulje

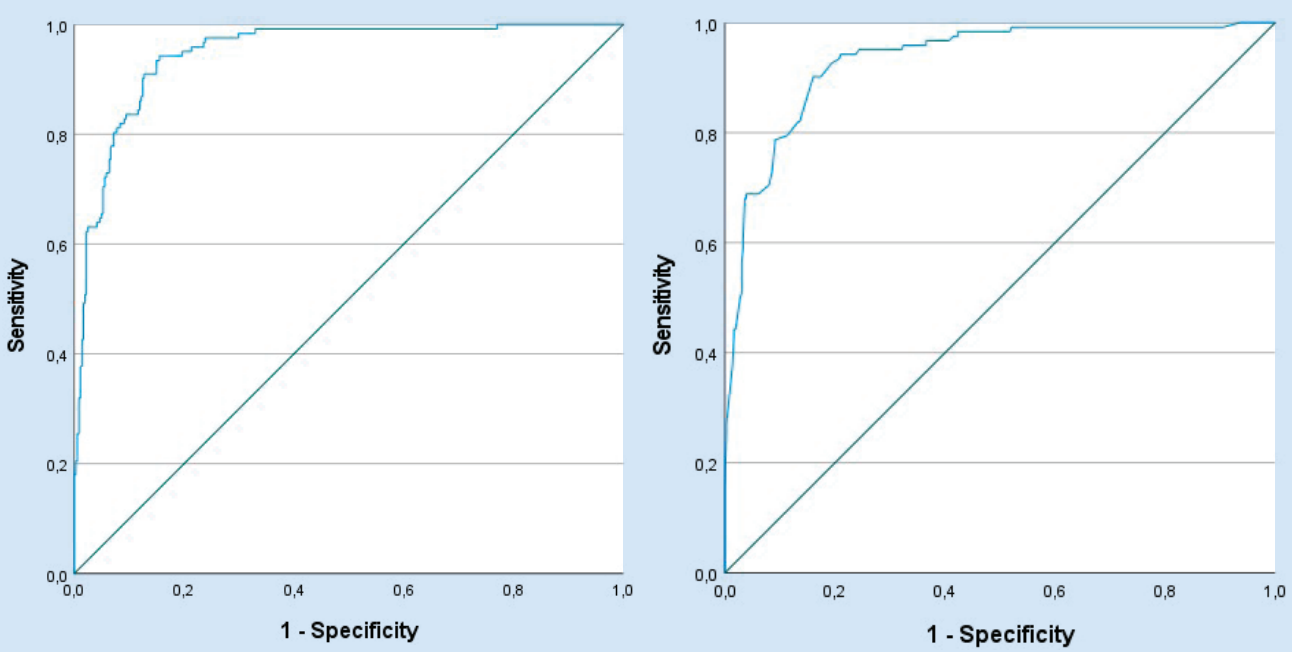

Figure 1 ROC curves for the age of 12 in the Portuguese population: **1a.** – European Regression Formula; **1b.** – Demirjian's Method. Figure 1 shows the ROC curves (Receiver Operating Characteristic Curve) for the European regression formula (1a.) and Demirjian's method (1b.). The figures display graphics of Sensitivity (True Positive Rate – correct positive results out of all positive samples) in the y axis and 1-Specificity (False Positive Rate – incorrect positive results out of all negative samples) in the x axis. It can be noted that figures 1.a. and 1.b. are very similar, however, the curvature of graph in 1.a. sits slightly higher than that of 1.b., resulting in a larger area under ROC curve (AUC). Specific results can be further observed in Table 3.

Slika 1 ROC krivulje za dob od 12 godina u portugalskoj populaciji: 1 a. – Europska regresijska formula; 1 b. – Demirjianova metoda. Na slici 1. su ROC krivulje (krivulja radnih karakteristika prijamnika) za europsku regresijsku formulu (1 a.) i Demirjianovu metodu (1 b.). Slike prikazuju grafiku osjetljivosti (stopa stvarnih pozitivnih rezultata – točni pozitivni rezultati iz svih pozitivnih uzoraka) na osi y i specifičnost 1 (stopa lažnih pozitivnih rezultata – netočni pozitivni rezultati iz svih negativnih uzoraka) na osi x. Može se uočiti da su slike 1. a. i 1. b. vrlo slične, no zakrivljenost grafa u 1. a. nalazi se malo više od one iz 1. b., što rezultira većom površinom ispod ROC krivulje (AUC).

an regression formula (10), only the variable *s* was used since the results were practically equal to those that would be obtained through the use of age estimates. It did not depend on the coefficients estimated by linear regression (which obtained different estimates through the application of Models 1 and 2).

Results for the cut-off point are shown in Table 3 and Figure 1.

Discussion

In intra-observer as well as inter-observer validation, the lowest values of 0.699 and 0.523, respectively, reached a satisfactory agreement, whereas most measurements, around 92%, reached an excellent agreement according to Fleiss (16).

For the European regression formula (10) method, the values for the fourth quadrant are very similar to those obtained for the third, though slightly less significant, meaning that in both quadrants the measures strongly correlate with age, hence can be used to estimate age. The same can be concluded when observing the strong correlation values found for Demirjian's (11) variable.

The average age estimation error and difference between chronological age and dental age of the present study, through the European regression formula (10), when comparing to those pertaining to the available literature, (Table 4), leads to the following observations: in Halilah *et al.*(17),

Rezultati za graničnu točku prikazani su u tablici 3. i na slici 1.

Rasprava

U validaciji između i unutar promatrača, najniže vrijednosti od 0,699, odnosno 0,523 postigle su zadovoljavajuće slaganje, a u većini mjerenja, oko 92 %, postignuto je izvrsno slaganje prema Fleissu (16).

Za metodu europske regresijske formule (10) vrijednosti za četvrti kvadrant vrlo su slične onima dobivenima za treći, iako malo manje značajne, što znači da u oba kvadranta mjere snažno koreliraju s dobi i zato se mogu koristiti za procjenu dobi. Promatrajući snažne vrijednosti korelacije nađene za Demirjianovu (11) varijablu, može se zaključiti isto.

Prosječna pogreška procjene dobi i razlika između kronološke i dentalne dobi u ovoj studiji, pri uporabi europske regresijske formule (10), u usporedbi s onima koje se odnose na dostupnu literaturu (tablica 4.), rezultira sljedećim opažanjima: kod dr.Halilah i suradnika (17), Latić-Dautović i suradnika (18), Luz i suradnika (19) te Shrestha i suradnika (20)

Table 4 Average Age Estimation Error and difference between chronological age and dental age
Tablica 4. Pogreška procjene prosječne dobi i razlika između kronološke dobi i dobi zuba

Author • Autor	Average Age Estimation Error • Pogreška procjene prosječne dobi	Difference between chronological age and dental age • Razlika između kronološke i dentalne dobi
Luz *et al.* [19]	- 14.28 ± 15.84 months (Croatia) - 12.6 ± 13.56 months (Brazil)	*p-value* < 0.001 (for both sexes in Brazil and Croatia)
Halilah *et al.* [17]	- 3.84 ± 11.52 months (female) - 6.72 ± 12.48 months (male)	*p-value* < 0.05
Latić-Dautović *et al.* [18]	-1.8 ± 9.36months (female) - 2.04 ± 8.76 months (male)	*p-value* = 0.002 (female) *p-value* = 0.001 (male)
Wolf *et al.* [21]	0.96 months (female) 0.84 months (male)	*p-value* = 0.480 (female) *p-value* = 0.314 (male)
Shrestha *et al.* [20]	- 2.16 months - 2.76 months (female) - 1.32 months (male)	*p-value* = 0.26 *p-value* = 0.35 (female) *p-value* = 0.54 (male)
Present study (European formula)	- 4.88 months (3rd Quadrant) - 4.04 months (4th Quadrant)	*p-value* = 0 (for the 3rd and the 4th quadrants)

Latić-Dautović *et al.*(18), Luz *et al.*(19) and Shrestha *et al.* (20), there was an underestimation of the average age, likewise in the present study. In spite of the discrepancy of the estimation error values, the difference between the estimated age and the chronological age for the 3rd and 4th quadrants found in the present study is close to the values found in Luz *et al.* (19). If we take into account the proximity of the aforementioned values as well as other values that have been analyzed, it seems that there have not been any statistically significant differences. It should be further noted that in the studies of Halilah *et al.* (17), Latić-Dautović *et al.* (18) and Luz *et al. (19)* there were statistically significant differences between the estimated age and the chronological age as observed in the present study (Table 4), whereas in the remaining studies, Shrestha *et al.* (20) and Wolf *et al.* (21), no statistically significant differences were found.

To better suit the Portuguese population, the second equation (Model 2) was obtained, by applying a linear regression on our sample. The adjusted R^2 obtained for this model explains the variation in age of 80.9% belonging to our sample. In turn, the adjusted R^2 obtained for the European regression formula (10) explained 86.1% of the age variation. Halilah *et al.* (17), on the other hand, obtained an adjusted R^2 of 0.87 for the German population. This value (87%) is closer to the one for the European regression formula (10) obtained by Cameriere (86.1%) than the value obtained through Model 2 (80.9%), although this is not a large discrepancy (5.2%).

Following the analysis of the models, the cut-off point was established in our sample. This point was obtained through the usage of ROC curves (Receiver Operating Characteristic Curve). It can be noted that the closer to 1 the value of the area under ROC curves is (AUC), the better and more precise its results are. In Table 3, it can be noted that all areas under ROC curves, upon using any of the aforementioned methods, obtained excellent results (all values above 0.93).

Regarding the sensitivity of the two applied methods, there appears to be a discrepancy of 11.48%, favoring the European regression formula (10). In terms of specificity, the discrepancy between the two methods is much smaller favoring Demirjian's method, though almost irrelevant, as it is as

dogodilo podcjenjivanje prosječne dobi, kao i u ovoj studiji. Unatoč odstupanju vrijednosti pogreške procjene, razlika između procijenjene i kronološke dobi za 3. i 4. kvadrant pronađena u ovoj studiji blizu je vrijednosti pronađenih kod dr. Luz i suradnika (19). Uzme li se u obzir blizina navedenih vrijednosti i ostalih analiziranih vrijednosti, čini se da nije bilo statistički značajnih razlika. Nadalje, treba napomenuti da u studijama dr. Halilah i suradnika (17), Latić-Dautović i suradnika (18) i Luz i suradnika (19) postojale su statistički značajne razlike između procijenjene i kronološke dobi kao što je uočeno u ovoj studiji (tablica 4.), a u ostalim studijama – onima Shrestha i suradnika (20) i Wolfa i suradnika (21) nisu nađene statistički značajne razlike.

Kako bi bolje odgovarala portugalskoj populaciji, druga je jednadžba (model 2) dobivena primjenom linearne regresije na našem uzorku. Prilagođeni R2 dobiven za taj model objašnjava varijaciju u dobi od 80,9 % koja pripada našem uzorku. S druge strane, prilagođeni R2 dobiven za europsku regresijsku formulu (10) objašnjava 86,1 % varijacije u dobi. Istodobno dr. Halilah i suradnici (17) dobili su prilagođeni R2 od 0,87 za njemačku populaciju. Ta je vrijednost (87 %) bliža onoj za europsku regresijsku formulu (10) koju je dobio Cameriere (86,1 %) od vrijednosti dobivene modelom 2 (80,9 %), iako odstupanje nije veliko (5,2 %).

Nakon analize modela utvrđena je granična točka u našem uzorku. Dobivena je korištenjem ROC krivulja (krivulja radnih karakteristika prijamnika). Može se uočiti da, što je vrijednost površine ispod ROC krivulja (AUC) bliža 1, to su rezultati bolji i precizniji. U tablici 3. može se uočiti da su sve površine ispod ROC krivulja, primjenom bilo koje od navedenih metoda, dale izvrsne rezultate (sve vrijednosti iznad 0,93).

Kada je riječ o osjetljivosti dviju primijenjenih metoda, čini se da postoji razlika od 11,48 % u korist europske regresijske formule (10). Što se tiče specifičnosti, razlika između dviju metoda mnogo je manja u korist Demirjianove metode, iako je gotovo irelevantna jer iznosi samo 0,56 %. Nakon promjene granične točke, njezinim podizanjem ili snižavanjem, moguće je pojačati jednu od tih mjera, a drugu u konačnici staviti u deficit, što znači da, unatoč rezultatima koji idu u prilog europskoj regresijskoj formuli 10, one imaju sa-

small as 0.56%. Upon changing the cut-off point, by raising or lowering it, it is possible to enhance one of these measures, ultimately placing the other in deficit, meaning that in spite of the results favoring the European regression formula[10], these hold only a mild significance. Nevertheless, a greater Youden's index was also obtained in the European regression formula, further pointing to the favorability of this method.

Overall, both methods obtained very good results; however, the European regression formula (2007) obtained slightly better results. The values obtained by Cameriere *et al.* (22) for the studied variables for the age of 12 years are similar to those obtained in our study.

Finally, Bayes PTP was calculated, which can be used to extrapolate the results of the present study to a population. Although the values appeared to be similar, the values for the European regression formula remained slightly superior, thus demonstrating that the European regression formula for age estimation has an apparently higher suitability compared to that of Portuguese population. As stated above, this method seems to be an appropriate method for age estimation of this particular age in the Portuguese population. Also, the results of the present study are relevant, since the Portuguese legal threshold age both for child liability when facing criminal charges and regarding child protection laws is 12 years of age (2,3). For this reason, the present study is of great importance to properly estimate the child's age when proper legal documentation does not exist (23).

Both a tutelary action that can come into effect if the child is considered liable of a criminal charge, and multiple rights regarding the child's own intervention in the proceedings surrounding their well-being when facing dangerous situations are dependent on the child being at least 12 years old (2,3). The results of the current study which were obtained using the European regression formula have confirmed the fact that this method can be perceived as a viable option for the estimation of the child's age for these proceedings.

Moreover, not only are the results of this study relevant to the Portuguese population, but they are also relevant internationally since this study, paired with numerous studies in which this formula was used by various researchers worldwide, brings us one step closer to the creation of an International formula that will aid in the quantitative estimation of a child's age, allowing for proof of legal identity, the protection of children's rights and universal access to justice and social services, thus being in line with UN's 2030 16th Goal (4).

Final Considerations

This is the first study to validate the reliability and legal application of the European regression formula [10] for the legal age threshold of 12 years in the Portuguese population. There are statistically significant differences between chronological age and dental age estimated by the European regression formula using the coefficients proposed by Cameriere *et al.* (10). There are no statistically significant differences between these parameters using the coefficients based on our sample. The European regression formula can be used for the Portuguese population. The estimated coefficients of Models 1 and 2 proved to be more accurate than Demirjian's methodology (11).

mo blago značenje. Ipak, u europskoj regresijskoj formuli dobiven je i veći Youdenov indeks, što dodatno upućuje na povoljnost te metode.

Sve u svemu, obje su metode omogućile vrlo dobre rezultate, no europska regresijska formula (2007.) pokazala se nešto boljom. Vrijednosti koje su dobili Cameriere i suradnici (22) za proučavane varijable za dob od 12 godina slične su onima u našem istraživanju.

Na kraju je izračunat Bayesov PTP koji se može koristiti za ekstrapolaciju rezultata iz ove studije na populaciju. Iako su se vrijednosti činile sličnima, vrijednosti za europsku regresijsku formulu ostale su neznatno veće, te se tako pokazalo da je ona pri procjeni dobi očito prikladnija u usporedbi s portugalskom populacijom. Kao što je navedeno, čini se da je ta metoda prikladna za procjenu dobi te određene dobi u portugalskoj populaciji. Rezultati ove studije također su relevantni zato što je portugalska zakonska dobna granica za odgovornost djeteta kada se suočava s kaznenim optužbama i u vezi sa zakonima o zaštiti djece od 12 godina (2,3). Zbog toga je ova studija veoma važna za pravilnu procjenu dobi djeteta ako ne postoji odgovarajuća pravna dokumentacija (23).

I tužba koja može stupiti na snagu ako se dijete smatra odgovornim za kazneno djelo, te višestruka prava u vezi s vlastitom intervencijom djeteta u postupku koji se odnosi na njegovu dobrobit kada se suoči s opasnim situacijama, ovise o tome ima li dijete najmanje 12 godina (2,3). Rezultati aktualne studije koji su dobiveni korištenjem europske regresijske formule potvrdili su činjenicu da se za te postupke ova metoda može percipirati kao održiva opcija za procjenu dobi djeteta.

Štoviše, ne samo da su rezultati ove studije relevantni za portugalsku populaciju, nego su važni i međunarodno jer nas ova studija, uparena s mnogobrojnim studijama u kojima su se tom formulom koristili razni istraživači diljem svijeta, dovodi korak bliže stvaranju međunarodne formule koja će pomoći u kvantitativnoj procjeni djetetove dobi te tako omogućiti dokaz pravnoga identiteta, zaštitu dječjih prava i univerzalni pristup pravosuđu i socijalnim uslugama, čime će biti u skladu sa 16. ciljem UN-a do 2030. (4).

Završna razmatranja

Ovo je prva studija koja potvrđuje pouzdanost i pravnu primjenu europske regresijske formule [10] za zakonski dobni prag od 12 godina u portugalskoj populaciji. Postoje statistički značajne razlike između kronološke i dentalne dobi procijenjene europskom regresijskom formulom s pomoću koeficijenata koje su predložili Cameriere i suradnici (10). Ne postoje statistički značajne razlike između tih parametara korištenjem koeficijenata na temelju našeg uzorka. Europska regresijska formula može se koristiti za portugalsko stanovništvo. Procijenjeni koeficijenti modela 1 i 2 pokazali su se točnijima od Demirjianove metodologije (11).

The European regression formula and the Demirjian method show similar results for the cut-off point of 12 years of age, however, there is a noticeable discrepancy favoring the European regression formula. The same occurs for Bayes PTP, and therefore, the Portuguese population. Considering the relevance of the 12 years of age as the Portuguese legal age threshold, the European regression formula is considered a viable methodology which can be used for the estimation of this age. However it has always pointed to the sensitivity of the results. This means that, for the institutions dealing with criminal law, the age assessment report should include how often the chronological age fallow inside the result obtained.

Conclusions

The results of the present study have confirmed the fact that the purpose of research is to generate new knowledge. The current study will contribute to the international database, thereby contributing to sustainability regarding age assessment by dental parameters, which is so important in law enforcement, notably in criminal jurisdiction.

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Conflicts of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethics approval

This study is performed in accordance with the ethical standards specified by the Health Ethics Committee of the Faculty of Dental Medicine, University of Lisbon, Lisbon, Portugal.

Author's contribution: **C.P.P.** - Constructing an idea or hypothesis for research and/or manuscript; **C.P.P., R.S., R.C.** - Planning methodology to reach the conclusion; **C.P.P., R.S, F.S.** - Organising and supervising the course of the project or the article and taking the responsibility; **C.P.P., R.S.** -Providing personnel, environmental and financial support and tools and instruments that are vital for the project; **F.S.** - Biological materials, reagents and referred patients; **C.B., J.S.** - Taking responsibility in execution of the experiments, patient follow-up, data management and reporting; **C.P.P., R.S., F.S., R.C.** - Taking responsibility in logical interpretation and presentation of the results; **C.B., J.S.** - Taking responsibility in this necessary function; **C.P.P., R.S., C.B., J.S.-** Taking responsibility in the construction of the whole or body of the manuscript.

Europska regresijska formula i Demirjianova metoda pokazuju slične rezultate za graničnu točku od 12 godina, no zabilježeno je primjetno odstupanje u korist europske regresijske formule. Isto se događa za PTP Bayes, a time i za portugalsko stanovništvo. Uzimajući u obzir relevantnost dobi od 12 godina kao portugalskoga zakonskog dobnog praga, europska regresijska formula smatra se održivom metodologijom koja se može koristiti za procjenu ove dobi. No uvijek se upozoravalo na osjetljivost rezultata. To znači da bi za institucije koje se bave kaznenim pravom izvješće o procjeni dobi trebalo sadržavati koliko često se kronološka dob nalazi unutar dobivenoga rezultata.

Zaključci

Rezultati ovog istraživanja potvrdili su da je svrha istraživanja generiranje novih znanja. Ova studija pridonijet će međunarodnoj bazi podataka, pa tako i održivosti kada je riječ o procjeni dobi prema stomatološkim parametrima, što je veoma važno u provedbi zakona, osobito u kaznenom pravosuđu.

Zahvale

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Sukob interesa

Autori nisu bili u sukobu interesa.

Etičko odobrenje

Ova je studija provedena u skladu s etičkim standardima Odbora za zdravstvenu etiku Fakulteta dentalne medicine Sveučilišta u Lisabonu, Portugal.

Doprinos autora: **C. P. P.** – predlaganje ideje ili hipoteze za istraživanje i/ili rukopisa; **C. P. P., R. S., R. C.** – metodologija planiranja za donošenje zaključka; **C. P. P., R. S, F. S.** – organiziranje i praćenje projekta ili članka te preuzimanje odgovornosti; **C. P. P., R. S.** – kadrovska, ekološka i financijska potpora te alati i instrumenti važni za projekt; **F. S.** – biološki materijali, reagensi i upućeni pacijenti; **C. B., J. S.** – preuzimanje odgovornosti u provedbi pokusa, praćenju pacijenata, upravljanju podatcima i izvješćivanju; **C. P. P., R. S., F. S., R. C.** – preuzimanje odgovornosti za logičnu interpretaciju i prezentaciju rezultata; **C. B ., J. S.** – preuzimanje odgovornosti u ovoj nužnoj funkciji; **C. P. P., R. S., C. B., J. S.** – preuzimanje odgovornosti za izradu rukopisa.

Sažetak

Uvod: Tijekom posljednjega desetljeća kaznenopravni sustav europskih zemalja bavi se novom skupinom ljudi – osobama bez dokumenata. Kada je riječ o kaznenome djelu, većina osumnjičenih tvrdila je da je prema vrsti kaznenoga djela maloljetna. Vlada svake europske zemlje dužna je štititi djecu i ranjive osobe. No pojavljuju se ozbiljni sigurnosni problemi zato što odrasli lažno tvrde da su maloljetnici, a pravni se sustavi protive takvim tvrdnjama. U ovoj studiji koristili smo se različitim metodama procjene dobi, a neke od njih nisu točne. **Cilj:** Kako bismo zadovoljili opća razmatranja, u studiji smo se koristili trenutačnim metodama procjene dentalne dobi. Zato, kada je riječ o portugalskom stanovništvu, ovoj je studiji svrha potvrditi europsku regresijsku formulu za dob od 6 do 15 godina, procijeniti graničnu točku za dob od 12 godina i usporediti kvantitativni pristup europske regresijske formule s Demirjianovim kvalitativnim pristupom za procjenu dobi. **Materijal i metode:** Europskom formulom i Demirjianovim stupnjevima bodovanja. analizirana su 483 ortopantomograma. Nova metoda – model 2, dizajnirana je tako da bolje odgovara portugalskom stanovništvu. **Rezultati:** Europska formula: podcjenjivanje prosječne dobi od 4,88 za treći kvadrant i 4,04 mjeseca za četvrti kvadrant i srednja apsolutna pogreška (MAE) od 10,93 mjeseca, odnosno 10,68 mjeseci. Demirjianova metoda: prosječno precjenjivanje od 8,70 mjeseci, MAE od 12,85 mjeseci. U modelu 2: MAE od 9,37 mjeseci za treći kvadrant i 9,28 mjeseci za četvrti. I europska formula i Demirjianova metoda imale su rezultate površine ispod ROC krivulja iznad 0,93. Razlika u osjetljivosti između metoda za određenu graničnu točku: 11,48. Rezultati dobiveni u ovoj studiji mogu se ekstrapolirati na 87,33 % portugalske populacije. **Zaključci:** Europska regresijska formula može se primijeniti na portugalsku populaciju i čini se da je u toj populaciji točnija od Demirjianove metodologije. Ipak, i europska regresijska formula i Demirjianova metoda daju slične prikladne rezultate u klasifikaciji dobi od 12 godina, iako postoji primjetno odstupanje u korist europske regresijske formule. Europska formula, kada se primjenjuje za procjenu kaznene dobi, neovisno o populaciji, obvezna je jer upozorava pravosudne institucije na osjetljivost rezultata.

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