

Medical, statistical, ethical and human rights considerations in the assessment of age in children and young people subject to immigration control

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Background: Unprecedented changes in both the scale and the complexity of international migration have led to international concern and controversy over the assessment of age in children and young people subject to immigration control or seeking asylum who say they are children yet have no documents to prove their stated age.

Sources of data: The article reviews the existing evidence on the reliability of medical and non-medical techniques for the assessment of chronological age.

Areas of agreement: There is evidence that radiography (X-rays) of bones and teeth, which is increasingly relied upon by immigration authorities, is imprecise, unethical and potentially unlawful, and should not be used for age assessment.

Areas of controversy: Medical techniques including X-rays continue to be relied upon in the absence of an alternative approach resulting in legal challenges and uncertainty for children and young people.

Areas timely for developing research: Further work is needed to establish a process for age assessment based on a 'holistic' multi-disciplinary approach which focuses not on chronological age exclusively but rather on the needs of children and young people subject to immigration control.

Keywords: children/asylum/immigration/age assessment

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Background

Age during the adolescent years is biologically unimportant: knowing whether someone is 14 or 19 years old has very little biological significance in view of the considerable range of normal physical development during adolescence. Moreover, there is significant physical and emotional variability, as well as in needs and vulnerability, between children of the same age who grow up even within the same ethnic, social and economic environment. Children and young people subject to immigration control come from cultures and contexts in which childhood is defined in different ways reflecting the social, economic and political circumstances of these societies. In many countries, births are not registered. Around 51 million children born in 2006 have not had their birth registered. Sub-Saharan Africa has the highest proportion of children under 5 years who are not registered—two of three. The largest number of unregistered children, however, is in South Asia: nearly 23 million.¹ Many children are, therefore, unable to produce documentary evidence of their age.

In contrast, age is a matter of considerable importance in the immigration context and particularly for those seeking asylum. A growing proportion of those crossing borders are children or young people separated from their families without documentary evidence of their age or status. A proven identity with the confirmation of chronological age is fundamentally important as age defines the relationship between an individual and the State and, in turn, the protection and/or support to which an individual will be entitled.² Children are entitled to welfare, health and educational support not available to adults and may be protected from detention and removal. Adults may say they are under 18 years of age so as to benefit from the more generous asylum policies and support arrangements for children. A child incorrectly assessed as an adult may be endangered if placed within an adult environment, while placing an adult incorrectly in a children's environment may expose children to risk. Some children have been unlawfully imprisoned in adult immigration detention centres because they have been deemed to be adults but subsequently found to be under 18 years of age.

In this context, it is vitally important that age assessments are accurate and fair. The difficulties facing immigration authorities in assessing age, and in balancing the consequences of making an incorrect decision, should not be underestimated. Across Europe, policymakers and officials are grappling with this complexity on a daily basis in settings such as border control posts and ports where they are subject to a myriad of other pressures. Perhaps, not surprisingly, the possibility that

medical techniques might be able to provide a 'straightforward' and 'objective' solution to this problem means that they are increasingly relied upon in the assessment of age. There is limited understanding of the ethical issues associated with these medical techniques and, most importantly, the fact that they are ultimately unable to give a precise assessment of an individual's chronological age.

The practice of age assessment in Europe

The Separated Children in Europe Programme (SCEP) has produced guidance on best practice for assessing age in children and young people subject to immigration control.³ Age assessment procedures should be undertaken only as a measure of last resort, once informed consent has been obtained. Professionals who are independent and have appropriate expertise and familiarity with the child's ethnic and cultural background, should undertake the assessment using a multi-disciplinary approach. Assessments should never be forced or culturally inappropriate and must respect the dignity of the individual. In cases of doubt, a person who says he or she is <18 years of age should be treated as a child.

Guidance on best practice in age assessment in Europe reflects the international standards for age assessment and the need to consider a child's best interests. The principle of best interests is integral to decisions which are taken in relation to children and young people.⁴ Although the 1989 United Nations Convention on the Rights of the Child (UNCRC)⁵ does not refer specifically to age disputes or assessment, General Comment No. 6 states that 'identification measures include age assessment and should not only take into account the physical appearance of the individual, but also his or her psychological maturity. Moreover, the assessment must be conducted in a scientific, safe, child and gender-sensitive, fair manner, avoiding any risk of violation of the physical integrity of the child and giving due respect to human dignity'.⁶ The UN High Commissioner for Refugees (UNHCR) has developed two sets of guidelines relevant to the issue of age assessment. In its *Guidelines for Unaccompanied Children Seeking Asylum*, UNHCR suggests that assessments should take into account both the physical appearance and the psychological maturity of the child, emphasize the need for accuracy, safety and dignity in the use of medical assessments, and recommends that authorities acknowledge inherent margins of error in medical assessments.⁷ The guidelines and their implications for practice are explored in detail elsewhere.⁸

Over recent years, the methods used to investigate the ages of children and young people subject to immigration control in Europe (and

elsewhere) have become the topic of lively international debate. The current practice of age assessment in Europe leaves much to be desired. The Council of Europe Commissioner for Human Rights, for example, has commented that methods for assessing the age of migrant children must be improved.⁹ A recent review of the practice of age assessment in Europe undertaken for UNICEF provides an overview of existing literature.⁸ The report focuses in particular on childhood as a cultural construct and identifies the key implications arising from the UNCRC. The review concludes that:

[t]here is too great a focus on attempts to determine a child's exact age even though age assessment is not an exact science and most involved commentators would acknowledge that whatever the method employed a significant margin of error must always be allowed. This search for certainty is often at the expense of assessing the child's psychological and developmental wellbeing as well as an indication of their age.

The European Migration Network similarly provides an overview of arrangements for age assessment in 22 EU Member States.¹⁰ This analysis shows that the Member States determine the age of individuals using one or more of the following methods:

- Interview and/or documentation (20 countries);
- Skeletal assessment (16 countries);
- Dental assessment (10 countries);
- Assessment by a doctor (7 countries);
- Psychological methods (5 countries).

The report does not contain detailed information about what is done by whom, or the protocols that are used. It is not possible, therefore, to examine the rigour of these methods. It is, however, clear that there is no consistency in practice. The report comments, for example, that in France in 2005–06, 25% of people who said that they were children were subjected to a medical examination under the order of the Public Prosecutor's Office (L'Office De Procureur). Conversely, in the Czech Republic, the high cost of such examinations means that there is no large-scale assessment of age. When an individual refuses to undergo an age assessment where one is demanded, he or she will be treated as an adult contrary to the SCEP's guidance on best practice.³ This raises important ethical issues.

In Belgium, there is a 'triple' test consisting of a clinical opinion of an experienced dentist coupled with radiographic examination of teeth, clavicles and hand and wrist. The procedure in Spain provides that Special Prosecutors for Alien Affairs are assigned the task of

co-ordination, supervision and transfer of the procedures to be followed. If there is insufficient evidence, the Prosecution Office can authorize medical tests, including wrist and hand radiography. The Spanish Ombudsman has recently laid before the Spanish Parliament a comprehensive review of the difficulties inherent in age assessment.¹¹

The SCEP has itself recently reviewed the current situation across 16 European Countries regarding the rights of separated individuals whose age is in dispute.² Even though age assessment is rarely based solely on one type of examination, the review indicates that the process almost never takes the form of a holistic assessment of physical, developmental and psychological factors, as well as environmental and cultural aspects. In particular, cognitive and/or behaviour appraisals and psychological interviews are generally not included in the existing procedures, which seldom engage fully with a child or young person's own account of his or her experiences and background.

Conferences and expert meetings in Oslo¹² and Brussels¹³ during 2010 and 2011 focussed on age assessment. Of special significance is the briefing document prepared for the UNICEF Child Rights Advocacy and Education Section in Geneva presented at the Brussels conference.¹⁴ Such meetings confirm the existence of considerable uncertainty as to best practice regarding age assessment, and the urgent need for further research.

The problems associated with the current approach to age assessment in Europe are reflected in the UK, where a comprehensive review of the existing evidence was produced by one of the authors (H.C.) for the Immigration Law Practitioners Association (ILPA).¹⁵ Published in 2007, this report gives important insights into the controversies over the UK government's approach to age assessment. As well as examining the implications and consequences of age disputes, it identifies child protection issues and makes practical policy recommendations. As such, it is a useful model for discussion in other countries.

In the UK, an initial assessment is usually made by an immigration official.¹⁵ If the official considers that an individual's physical appearance, narrative and overall demeanour suggest that he or she is 'very significantly' over the age of 18 years, the applicant is treated as an adult. If it is thought that the individual may be a child or is close to 18, he or she will be referred to a local authority in order that an age assessment can be undertaken by a social worker. The concept of 'Merton compliance' has been introduced in the wake of the decision in *R(B) v London Borough of Merton*.¹⁶ In practical terms, the effect of the concept of Merton is that two trained social workers are expected to perform an assessment of the applicant's physical appearance, social development, their account of family life and educational history. If this assessment suggests that the individual is under the age

of 18 years, then this is usually accepted by the UK Border Agency unless there is credible (usually documentary) evidence to the contrary. In 2008, 1400 applications were 'age disputed', of which approximately half were subsequently assessed to be children.¹⁵ It should be noted that, while social workers are independent of the immigration authority, there is some evidence of a potential conflict of interest where the outcome of the age assessment process has financial implications for the local authority that will be expected to support an individual whom they assess to be a child.¹⁵

There have been important legal and procedural developments since the ILPA research was published. For example, there has been increasing involvement of the courts, including the Supreme Court (previously the House of Lords), with key judgements concluding that the responsibility for determining age in disputed cases ultimately lies with the court.¹⁷ Moreover it was recently revealed that over £2 million had been paid in a court settlement in 2010 to 40 child asylum-seekers who were wrongly detained as adults as a result of a flawed process of age assessment.¹⁸ In this context, it is important that legal representatives fully understand the age assessment process, especially the medical practices that are undertaken.

There have also been developments in relation to the use of X-rays in the process of age assessment. Parliamentarians and others in the UK have long contested the use of X-rays in the age-determination process, primarily on the basis that such methods are both imprecise and unethical. Despite this, in 2006, the UK Government proposed in evidence to Parliament that X-rays of the hand, wrist and teeth should be considered as part of the examination process. One of the authors (A.A-G.) while serving as Children's Commissioner for England, facilitated substantial opposition to this from all relevant professional bodies and organizations, and their views were conveyed to an Age Assessment Working Group set up by Government to advise it on an agreed approach. The conclusions of this Working Group have not been published, but the evidence presented led to the retraction of the proposal. Radiography is not currently part of the routine screening process for age assessment in the UK, this position being re-stated in a House of Lords debate in March 2009.¹⁹ It should be noted, however, that the use of X-rays to assess age is once again under consideration. In March 2012, the UK Border Agency announced a trial using dental X-rays to assess the age of asylum-seekers claiming to be children whose age is disputed. This trial has met with vigorous opposition on medical, statistical and ethical grounds.²⁰ The medical and ethical issues surrounding the use of X-rays for the age of assessment are explored in further detail below.

Notwithstanding considerable research, policy work and advocacy, age assessment practice in the UK remains highly inconsistent.²¹ As noted above, this lack of consistency is a feature of age assessment practice in Europe. Consequently, the conclusion as to an individual's legal age in one country could well be disputed or revised should the individual move to another Member State. There is anecdotal evidence that individuals accepted as being children in one country have been re-assessed as adults in other countries.

Ethical considerations

Before considering the extent to which the existing approaches are able to provide a precise assessment of chronological age, it is important to first consider the context within which age assessments take place and any ethical issues with which they are associated. Of course, the ethical issues raised by age assessment and the methods employed cannot be divorced from the framework of principles of medical ethics. Bioethics, a branch of moral philosophy, comprises four guiding principles: respect for autonomy, beneficence, non-maleficence and the principle of justice.²² These principles may be accorded varying weight and the appropriate application of the values will be subjective in any given clinical situation. However, the principles can serve as tools to assist in the handling of the situation, the reaching of any decision and subsequent analyses of decisions previously made.²³

Although there is a common thread running through the principles of medical ethics and human rights, there is a disagreement as to how exactly they are connected. They share fundamental similarities, such as protection of the vulnerable encompassing respect for individual autonomy. But there are also important differences: medical ethics feature significantly in relations between private individuals, whereas human rights operate in relations existing between private individuals and the State. Human rights law tends to set specific minimum boundaries of acceptable treatment between the State and individuals, whereas principles of medical ethics are more flexible and relate to a relationship typified as a norm having the best interest of the patient as the fundamental consideration.

It could be said that the values in medical ethics are complementary, and in some cases identical, to those inherent in human rights legislation. Principles of morality developed into broader ethical values which, in turn, have evolved over time into a codified system of protection expressed in human rights legislation. The Hippocratic Oath, which forms the basis of many medical codes such as the International Code of Medical Ethics, contains general principles that are relevant to

both modern values of medical ethics and human rights law. Although the exact nature of the relationship between human rights and medical ethics is outwith the remit of this article, some of the techniques used in age assessment, particularly radiographic imaging and physical examination to establish sexual maturity, raise particular ethical issues.

In considering the ethics of radiography, it is necessary to weigh up the actual or potential benefits of radiography with the potential damage that might be caused to a group of children and young people who are potentially vulnerable, as a consequence not only of their age, but also their background and experiences. On the basis of the available evidence, it is clear that the use of radiography for age assessment for administrative as opposed to medical purposes is not only imprecise, but also unethical and potentially unlawful.

First, imaging of bones or teeth can never indicate precisely the chronological age of the individual. All that it is able to do is to provide an estimate of the degree of maturity the person has experienced when compared with images from control subjects, and within the very substantial range of normal development during adolescence. The methods used were not designed to assess disputed chronological age—they were prepared for medical use in diagnosing and monitoring disorders of growth.

Second, the assessment of age should be undertaken through a comparative assessment of the image of the individual against standards of normality for the population from which the person originates. Such standards are simply not available for children and young people from many countries in Asia, Africa or the Middle East, and it is unsatisfactory to assess their images from the standards derived from Caucasian, European or North American children. Even when comparative normative images exist, at best chronological age correlates to ± 2 years of maturity age. In some entirely normal children, this may be discordant by as much as 4–5 years.

Third, although superficially easy to do, radiography demands expert interpretation by experienced paediatricians, dentists or radiologists.

Fourth, X-rays are associated with a radiation dose that, in the assessment of age for children and young people subject to immigration control, is driven solely by a government's administrative convenience and is without therapeutic benefit to the individual. Even though the radiation dose from an X-ray of the hand is small (equivalent to 0.00017 mSv, i.e. 1-h exposure to background radiation in many cities),²⁴ radiologists, dentists and others cannot simply downplay the effects of 'a little bit of radiation' but rather must consider the As Low As Reasonably Achievable (ALARA) principle. This describes the evaluation that medical practitioners have to conduct before supplying an X-ray, or another procedure which emits radiation. Medical

practitioners have to consider whether or not the advantages outweigh the risks of inflicting radiation upon an individual. This is because ionizing radiation is a consistently identified and potentially modifiable risk factor for meningioma (brain tumour).^{25,26}

Finally, such estimations should be performed only with the fully informed consent of the individual. Performing medical procedures without this consent is, in the UK at least, unlawful and could lead to practitioners facing legal charges of assault and professional misconduct. In the immigration context, ensuring that full and informed consent is obtained is complicated by cultural, religious and linguistic factors, often coupled with a general lack of understanding of medical environments. Currently, the law on consent with regards to children is concerned with not only the age of the child, but also the maturity of the child and his or her ability to make an informed decision about the proposed procedure.²⁷ Although there may be compelling reasons for age assessment, it remains of paramount importance that children and young people from different backgrounds are provided with appropriate information and legal advice. Only then can a valid and informed decision be made.

Growing concern that age assessment by the use of radiography is imprecise, unethical and potentially unlawful has led every relevant statutory and professional body in the UK to argue against its use. These include:

- Professional organizations including the British Medical and Dental Associations;
- Statutory regulatory bodies including the General Medical and Dental Councils;
- The Royal Colleges of Paediatrics and Child Health and Radiology who are responsible for professional training and standards;
- Senior officials in the government's own Department of Health; and
- Specialist societies including the British Society for Paediatric Endocrinology and Diabetes, and the Council of the European Society for Paediatric Endocrinology (ESPE).²⁸

As noted above, the weight of this expert opinion led the UK Government to retract its intention to promote X-rays for age assessment. This position was re-iterated in March 2009 by the Minister for Immigration during a debate in the House of Lords.¹⁹ Similar concerns have been raised elsewhere. Engagement with the ESPE has revealed that many paediatric endocrinologists—experts in growth and sexual development—are unaware of the practices on age assessment in their countries and have not been involved in the design of protocols. The Council has, however, issued a robust Position Statement that skeletal

and dental maturity should not be used for the assessment of chronological age.²⁹ In Australia, the Royal Australasian Colleges of Physicians and Radiologists and the Australasian Paediatric Endocrine Group have declared their opposition to radiology in age assessment³⁰ and challenged the government for not involving them in discussions on policy. The International Olympic Committee and Federation Internationale de Football Association (FIFA) have also agreed that radiology should not be used to assess age, a stance supported by, amongst others, the World Health Organization.²⁴

Despite this, X-rays to establish bone and dental maturity continue to be used widely in EU Member States and elsewhere.^{2,8} One possible explanation is that some radiologists, dentists and others are able to generate income from performing and assessing the X-rays of children and young people subject to immigration control. Another explanation is that some medical practitioners are unaware of the methodological problems associated with the bone and dental assessment for estimating chronological age and may believe that their interventions are 'helpful' to children and young people who are subject to immigration control. In this context, radiologists and dentists may choose to downplay the imprecise nature of medical techniques for the assessment of age and ignore the potential consequences for children and young people who are subject to them.

Approaches to the assessment of age

Having outlined policy developments in the UK and Europe and the broader medical and ethical framework within which these developments should be understood, this article now turns to the specific approaches currently used for the assessment of age in children and young people subject to immigration control. There are currently three main approaches to the assessment of age. The first, which can best be described as non-medical, incorporates an evaluation of existing documentation, a visual assessment based on physical appearance and interviews that provide a narrative about an individual's life and circumstances. The second approach is essentially medical and includes physical examination (anthropometry and sexual development) and imaging of bones and/or teeth by radiography. The third approach seeks to integrate the data from both non-medical and medical approaches, recognizing that multidisciplinary collaboration is a prerequisite to ensure good outcomes for vulnerable children and young people. It is within this context that health professionals have rejected the routine use of radiology, as discussed below. The sections that follow examine the evidence in relation to each of these approaches

and their potential to deliver a precise chronological age for a child or young person subject to immigration control.

Non-medical approaches

Non-medical approaches to age assessment are most typically undertaken by immigration officials at border entry points. They include the evaluation of the existing documentation that may indicate an individual's age, a visual assessment based on physical appearance, and narrative interviews. The analysis of existing documentation is fraught with difficulties owing *inter alia* to a lack of training provided to staff, especially at border crossings, about the processes and use of age-related documents in the countries from which applicants have arrived. Practical concerns over the credibility of the documents and the possibility of them being forged or belonging to someone else are also associated with a 'culture of disbelief' which can result in a prematurely prejudiced assessment of an individual's age.¹⁵

An individual's narrative about his or her experiences can be important in assessing age, but a properly conducted analysis demands time, often involving several separate interviews, together with effective training and expertise in the country from which person originates. It is important that the interviewer comes away from the interview with a proper understanding of the individual's life, education and cultural background and experiences to date. An intimidating environment, the rigour of the process and the attitudes of staff conducting the interviews may compromise the potential value of an interview in establishing an individual's age.^{2,3,4,15}

Medical approaches

It is important for both children and the immigration authorities of the countries to which they move that there is an appropriate and consistent approach to the assessment of age. In this context, governments are keen to identify a 'scientific' method that will provide them with a precise chronological age of an individual and enable them to act accordingly. Unfortunately, there is no 'scientific method' that can provide a precise assessment of chronological age in individuals between 15 and 20 years of age—the very group for whom the issue of age assessment is most salient.

There are fundamental problems associated with the use of medical techniques to assess age methods, and their limitations must be acknowledged and confronted. All too frequently, the nuances of

medical approaches to age assessment are not readily understood by policy makers, let alone by staff inside and outside of clinical medicine, who may deny the implication of these difficulties. Most notably:

- (i) In many countries including the UK, the critical age pre-occupying policy and practice is 18 years; under 18 years, the individual is judged to be a child while more than 18 years to be an adult. However, the central difficulty in interpreting data is the very wide range of the timing of normal growth, sexual development, and bone and tooth maturity during adolescence;
- (ii) The influence of ethnicity, genetic background, nutrition, deprivation, previous and current illnesses—especially endocrine diseases—which can all have profound effects on physical development, skeletal and dental maturity. For example, in some families, adolescent development may be advanced or delayed compared with the average child and in some ethnic groups, stature is naturally taller than in others. Disorders of hormone secretion can have powerful effects on stature and sexual maturation leading to either early or late physical development.

Several different techniques feature within medical approaches to age assessment including physical examination, the use of X-rays to determine skeletal (bone) and dental maturity, and the use of other methods of imaging bone development. This section considers each of these techniques in turn and considers the medical, statistical, ethical and human rights issues associated with their use in the assessment of age in children and young people subject to immigration control.

Physical examination

In some countries, a physical examination by a doctor is included in the assessment to obtain anthropometric measurements of height, weight, skin-fold thickness and stages of sexual development.^{2,8} However, none of these measurements by themselves gives a reliable assessment of age. Moreover, the assessment of sexual development is highly intrusive and ethically questionable when conducted without medical or therapeutic benefit.

Figure 1, based on the British 1990 growth reference,³¹ illustrates a typical growth chart used in the UK that also incorporates stages of puberty. A wide range of different charts is in use in different countries including those from the Centers for Disease Control in the USA and the World Health Organization, and practitioners using these charts must be aware of their provenance and limitations. The chart shows the ranges of height and weight obtained by measuring large numbers of British children at different known ages. The 50th centile line is the average for each age, the 2nd and 98th centile lines representing +2 and -2 standard deviations (SDs) from the mean. This means that 4% of normal children can expect to have a height outside this range.

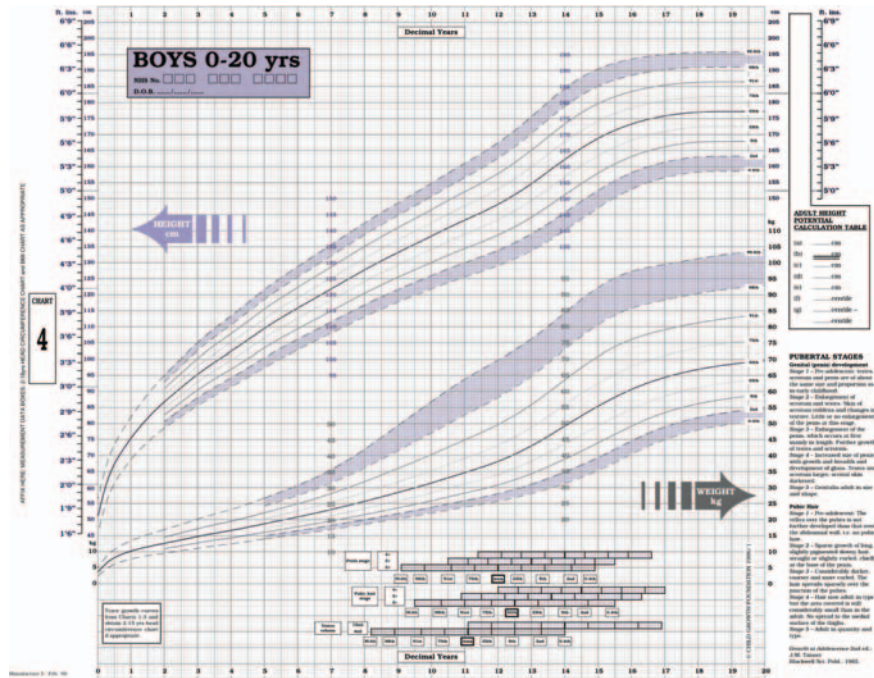


Fig. 1 British 1990 growth chart for height and weight in boys 0–20 years (Child Growth Foundation) with permission. This also includes the range of sexual development characterized by penile length, pubic hair stage and testicular volume. A similar chart exists for the growth and development of girls aged 0–20 years.

However, note that at the age of 14, 5% of normal boys have heights above the average for adults.

Paediatric endocrinologists use growth charts in two ways:

- (i) Height measured on a single occasion. This allows a ‘one-off’ estimation of the height achieved at that particular age;
- (ii) Sequential measurements to assess growth rate (velocity). If reliable measurements over an interval of not less than 6 months show evidence of growth, then the person cannot be fully mature.

Two or more measurements at least 6 months apart provide good evidence for or against continued linear growth, whereas single measurements are in many cases uninformative, for the reasons given above.

It is important to understand that in age assessment, the chart is used ‘the wrong way round’. If age is not known, the chart shows what range of ages is compatible with a given height. The shortest normal male adults are ~160 cm in height, and therefore any individual presenting with a height >160 cm could be adult. Equally, this height can be seen in very tall boys as young as 11 years. So, unless the applicant

is shorter than 160 cm, their height, measured on a single occasion, provides little information about their likely age.

Details of the classification scheme for assessing sexual maturation can be found in Marshall and Tanner³² and in pictures, for example, Wales *et al.*³³ Figure 1 also shows the wide range of normality for the physical signs of adolescence in boys, i.e. Tanner staging of pubic hair development, and penile length, together with testicular volume as measured with a Prader orchidometer. According to these classifications, sexual development in girls is assessed by:

- Age of menarche (first menstrual period);
- Pubic hair stage—amount and distribution of pubic hair;
- Amount of breast development.

And in boys by:

- Penile length;
- Testicular volume;
- Pubic hair stage—amount and distribution of pubic hair.

Testicular volume is measured by comparative palpation of the individual's testicle against the volume in millilitres of prosthesis that most closely matches it.

It is important to understand that as with physical growth more generally, physical signs of puberty do not correlate closely with the chronological age. Just as importantly, intimate genital examination for administrative purposes may be, and most likely is, experienced as abusive. Sexual development is an issue of intense privacy and sensitivity for most adolescents, particularly in those from certain cultural and religious backgrounds. Moreover, asylum-seeking children and young people may have experienced the trauma of female genital mutilation, rape or other sexual violations.

This raises important ethical issues over the propriety of such examinations especially when they are conducted for administrative purposes alone. The lack of medical benefit is not, in itself, necessarily a reason for ethical concern. However, it becomes a concern when its absence is reinforced by knowledge that such intimate examinations, which cause difficulty in many adults, may lead to psychological harm for some children. Ethically, there is a dilemma in striking the balance of effective assessment of individuals passing through borders, and ensuring no harm is experienced by those assessed. As discussed earlier in relation to radiography, it is important to assess a child's autonomy and whether he or she possesses sufficient capacity to consent to or refuse to such intimate examinations. In this context, self-assessment of sexual development could be an alternative approach, but this requires

validation, not least in testing the reliability of the reports should the age dispute be referred to the courts.

X-rays to assess skeletal maturity

The Atlas method of assessing skeletal maturity was published by Greulich and Pyle in 1959 using X-rays from largely white, middle-class American children taken in the 1930s.³⁴ The Atlas builds on earlier work by Todd³⁵ and comprises a series of pages with a representative X-ray (radiograph) from a single child of known age on each. The radiologist then takes the X-ray from the individual being assessed and turns the pages to find the X-ray that most closely corresponds to it. The chronological age of the child in the Atlas radiograph is then attributed to the individual's X-ray (Figure 2a,b,c).

Growth takes place at the ends of each long bone where there is an ossification (bone development) centre with a growth plate or epiphysis of soft bone (cartilage). As the child's wrist develops, sequential changes occur in the amount of bone being laid down in the cartilage of the wrist and finger bones (the white substances in the images), and sex hormones during adolescence lead to deposition of bone in the growth plates. This leads to 'epiphyseal closure' after which no further growth can occur, the bones being fully mature. If there is clear evidence of linear growth from measuring a child's height sequentially, then the epiphyses cannot be closed and therefore the individual is not fully mature.

Although the results of this method are often presented as 'scientific' and 'objective', it is in fact highly subjective with a considerable inter-observer range of 'ages' given by different radiologists. Furthermore, the reference X-rays are not derived from contemporaneous children, but reflect the speed of bone development in a selected group of children over 70 years ago. Although other bones are also often assessed, for example, the clavicle or elbow, the X-ray of the wrist remains the one most commonly used.

A clear misunderstanding of the statistical interpretation of a Greulich and Pyle age assessment by a government-appointed radiological expert in a legal case in Australia led one of the authors (T.J.C.) to comment that '[t]he use of the Atlas in this way is inappropriate and the conclusions drawn are wrong...'.³⁶ He also states that:

The average age of 19 years for a mature X-ray as used is itself meaningless, since it can be seen at any age between 15 and 95+ years. What is needed is the mean age of attainment of a mature X-ray, i.e. the mean age at which the X-ray becomes mature. This age will be earlier by definition (the earliest age it can be seen in the individual), which will increase the probability of being <18 years. However it is not given in the Atlas, nor is it even considered there. It is important to realise that the

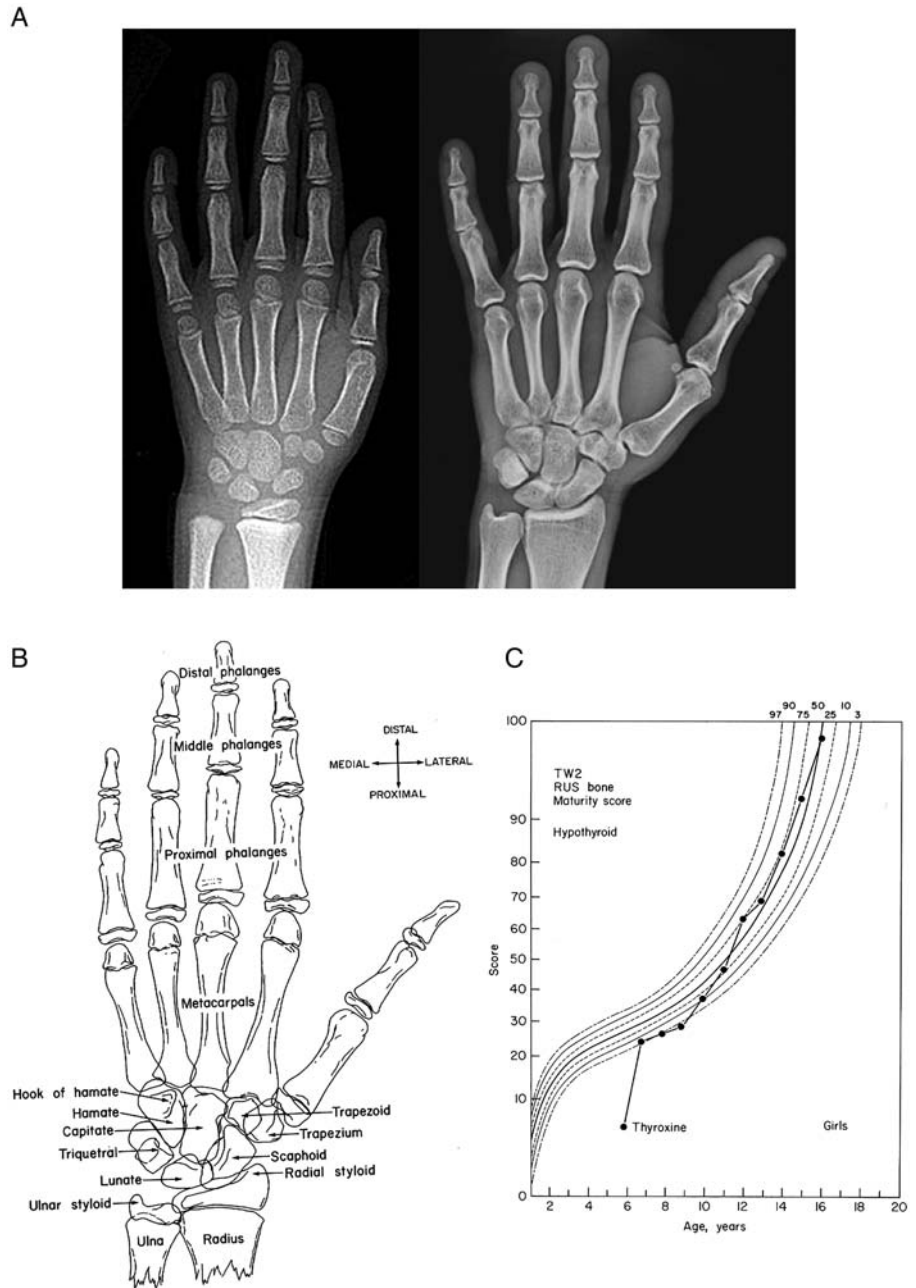


Fig. 2 (A) Radiographs of two individuals, that on the left being a young child aged 6 years and that on the right being an adult who has reached skeletal maturity. (B) The bones of the hand and wrist (with permission).³⁷ (C) The range of distribution for the RUS score by age from which it can be seen that the average age when full maturity occurs in girls is between the ages of 15 and 16 years, but this can range from 13 to nearly 18 years (with permission).³⁷

Atlas's purpose was to estimate bone age in growing children. Greulich and Pyle had no interest in children whose X-rays were mature, as they could not ascribe a bone age to them. So they excluded such children from their calculations.

T.J.C.'s comments along with other evidence culminated in a number of individuals, who had been identified as adults on the basis of one wrist X-ray, being released from adult prisons. These developments triggered a Federal Government public enquiry into the process of age assessment in Australia at the end of 2011, and a further enquiry by the Australian Human Rights Commissioner. The results of these enquiries are awaited with interest.

In an attempt to improve the reliability and precision of the radiological approach for bone age assessment, Tanner and Whitehouse introduced a more complex process in 1962,³⁷ the TW2 method, in which the individual bones of the hand and wrist (Fig. 2b) are scored against pictorial and written criteria from the X-rays of 2700 British lower- and middle-class children. The total score is calculated as a score for the radius, ulna and short bones (the RUS score) and entered into centile charts similar to growth charts (Fig. 2c). The data for this method were updated in 1995 and then in 2001 as the TW3 version to accommodate the marked secular changes that have occurred in the speed of bone development during the last 30 years. The TW2 and TW3 methods also require a dose of radiation, although they do reduce inter-observer variability very slightly.

Figure 2c also shows the trajectory of bone development in a child found to be suffering from hypothyroidism, an underactive thyroid gland. At the age of 6 years, she had grossly retarded bone development, but as treatment was introduced her bone 'age' rapidly increased, and with titration of the dose of treatment against growth and bone development, she achieved an average adult height with normal bone maturity. This is one example of the major effects that endocrine disease can have on growth and bone development.

The key conclusion to be drawn from this evidence is that the maturity 'age' from an X-ray does not necessarily translate to the same chronological age, and that, as a result, this is not a reliable method by which the age of a child or young person can be accurately assessed.

X-rays to assess dental maturity

An orthopantomogram is an X-ray of the teeth. As with skeletal development, there are sequential changes in the eruption and structure of teeth during childhood growth. By the age of 14–18 years, all of the teeth, except the third molars, or wisdom teeth, are fully formed, the

latter showing a wide range of the developing crown and root. Owing to their late development, the third molars are the ones most often examined when estimating age. Third molars mature at a later age than other teeth; however, their development is more variable than for all the other maturity markers, and in addition, some individuals do not grow their third molars at all. In some individuals, matured (stage H) third molars can be seen as early as 15 years of age, while, in others, the third molars may have not appeared at all even at 25 years.

There is considerable controversy over the accuracy of dental X-rays for assessing age. A range of different methods for assessing age through the use of dental X-rays have been reviewed by Schmeling *et al.* in the German Study Group on Forensic Age Diagnostics.³⁸ Liversidge³⁹ has shown that using the classification system of Moorrees *et al.*,⁴⁰ there is a significant difference in the development of third molars between White and Bangladeshi children from London and Black African and Cape-coloured children in South Africa. Thevissen *et al.*⁴¹ examine data from nine country-specific populations and conclude that although there are differences in speed and onset of development, the differences were small and not consistent over the considered age ranges. In a further study, they conclude that using Belgian instead of country-specific information increased the percentage of correctly identified juveniles, but decreased the percentage of correctly identified adults.⁴² Liversidge⁴³ also reports on studies by using Demirjian and Goldstein's method to interpret group differences from a very large database of children of European origin in eight countries. She concludes that there is a wide 95% confidence interval for each stage of maturity and that the statistically significant differences do not reflect any biological differences at the population level.

Roberts *et al.* have suggested a 'simple' scoring system in which each individual tooth is scored against criteria.⁴⁴ In a critical commentary on the statistical validity of the interpretations and conclusions of this method, Cole highlights a lack of rigour in understanding the statistical basis for the method.⁴⁵ He focuses in particular on the difficulties in assessing third molar teeth with the last two G and H stages. These two stages bracket the age of 18 years, stage G having a mean age of 17.5 years, with a 95% confidence interval of ± 2.8 'years'. Yet, stage H can be seen in emerging adults of 15, while stage G as late as 23 years. Cole concludes by stating categorically that X-rays of teeth are not suitable for age assessment. This conclusion prompted Aynsley-Green to argue that radiological assessments of dental maturity are imprecise, not fit for purpose, unethical and potentially unlawful.⁴⁶ Roberts and Lucas responded to these criticisms by refuting the implications of ethnicity for dental age and suggesting that dental age assessment correlates more closely with the chronological age than any

of the other methods such as skeletal age, height, weight, psychological assessments and assessments of sexual maturity.⁴⁷ However, the authors' main examples relate to dental age in those under 16 years of age so do not apply to third molars. The British Dental Association is vigorously opposed to the use of dental X-rays to assess age.⁴⁸

There is, clearly, considerable controversy amongst dental experts on the reliability and validity of the different methods for assessing dental maturity. The wide range of variability in the timing of dental development, the need or otherwise to take ethnic differences into account, and the applicability of population standards to the assessment of the individual in the border setting create real challenges for those trying to define best practice.¹⁵ On the basis of the existing evidence, we conclude that routine dental radiology is not acceptable for the assessment of age in children and young people subject to immigration control. To get around the problem of inaccuracy, Schmeling *et al.* recommend physical and dental examination coupled with X-rays of the left hand and dentition, with additional X-ray of the clavicle in subjects where the hand X-ray shows complete skeletal development.³⁸ This approach, which increases the numbers of X-rays, should be challenged in view of the ethical dimensions of radiography discussed above.

Other methods of imaging bone development

The use of non-ionizing radiation methods including magnetic resonance imaging (MRI) and ultrasound is attractive, not least because these methods are utilized in other contexts where age is disputed. In international-level competitive sport for example, most activities are classified on the basis of chronological age to ensure more equal chances of success. Increasing maturity is associated with greater strength and endurance, so it is important that competitors are at the age that they say they are. Allegedly some competitors understate their age on key official documents. This has led the International Olympic Committee to issue guidance.²⁴ FIFA has also been concerned with age verification of players in Under 17 tournaments through its Medical Assessment and Research Centre since 2003⁴⁹ and has explored the use of MRI scans to assess the age of competitors where this is disputed.⁵⁰

Although non-radiological methods are claimed to show greater inter-observer reliability, emerging evidence suggests that they underestimate bone maturation when compared with X-rays. Accordingly, the same reservations must apply in that there will also be very considerable variation in the MRI-assessed rate of bone development during adolescence and age of attainment of maturity. Further research is needed to validate the MRI approach to assessing age in normal populations before considering its use as a routine method for children and young people subject to immigration control. Furthermore, the

technology demands expensive equipment and specialist expertise limited to few locations.

Finally, because it is low cost, non-radiological, portable and easy to use, commercial interest has been expressed in the use of ultrasound for wrist bone development.⁵¹ Nevertheless, questions remain regarding its reliability and reproducibility, together with the same concerns over the effects of ethnic differences when coupled with the range of normality for bone fusion. To date, there is no good information on the application of this technique to age assessment of children and young people in the immigration context.

The combined or 'holistic' approach

The third, increasingly popular, approach brings together aspects of both the non-medical and the medical approaches but excludes radiography. Birch has published an 'alternative' approach based on the statistical argument that aggregating a number of different measurements each with a wide confidence interval improves precision in the results obtained by narrowing of the overall confidence interval.⁵² The report provides an account of how a paediatrician conducts an evaluation of growth through measurements, physical examination, sexual development, dental inspection (without X-rays) and emotional and cognitive development. The report states that the assessment of psychological and mental ability is very difficult in individuals who have little or no education, come from a different cultural background and who may have experienced trauma. The study tested the combined approach through a 'Monte Carlo' statistical simulation, concluding that if the standard deviation (SD) of each of the five parameters is in the order of 2.1 years, combining the data leads to a reduction of SD to 11 months. This approach has been field tested on 133 children in Afghanistan who have documented birth dates. Although thought-provoking, this method requires further independent validation. The statistical assumptions have been challenged in UK High-Court cases, but the most serious challenge relates to its alleged general applicability since so much of the final conclusion depends upon the 'clinical experience' of one practitioner.

More generally, the combined or 'holistic' approach raises important questions about the importance of involving paediatricians in the process of age assessment. In the UK, this has roused considerable controversy. Age assessment has historically been conducted by the immigration authorities and social services, without the involvement of paediatricians. Young people who have disputed the outcome of their assessment have sought paediatric opinion, which has been vigorously

challenged in the courts.¹⁷ Paediatric evidence has been criticized for not being based on rigorous protocols or sound and auditable methods, and for being overlaid by subjective opinion or ill-defined 'clinical experience'. In this adversarial context, very few paediatricians have been prepared to be involved in age assessment. Paediatricians, like social workers, have not had a sound evidence based on which to ground their assessments and this remains a fundamental difficulty that requires to be addressed as a matter of urgency.

There are particular difficulties from a paediatric viewpoint raised by the unusual nature of the age assessment question. Thus, research and routine clinical practice is focussed on separating normality from disease to recommend appropriate intervention in the interests of the child's health. Specific consideration is required to answer the quite different question about an individual's likely age. The statistical combination of observations from different domains to improve the accuracy of age assessment and to narrow the margins of error within an assessment is another significant area of current uncertainty, with no methodology currently gaining peer-reviewed recognition in this regard. A third level of difficulty is in the ethical application of assessed age, with its attendant uncertainty, in reaching decisions that will have life-long effects on the individual.

There is a value in paediatric assessment despite these difficulties. At the most obvious level, the current system is unable to tell if a child has grown several inches while the authorities dispute age. Based on our collective knowledge and experience, we are of the view that paediatricians have unique skills that allow them to make an important contribution in a holistic and multi-disciplinary approach to age assessment. Paediatricians are skilled in taking clinical histories; they are well used to the principles of growth assessment and understand normal and abnormal physical, sexual and psychological development in children and adolescents. Paediatric endocrinologists are paediatricians who specialize in understanding normal hormone secretion in childhood and the disorders that follow from abnormal secretion. Such disorders can have profound effects on the speed of growth, skeletal maturation and sexual development. X-rays of the skeleton are used routinely to investigate such disorders and to monitor treatment.

Of special significance in the UK is the routine involvement of paediatricians with young people requiring statutory safeguarding, including those who enter the care of local government. National policy recognizes that outcomes for children and young people are better where there is an effective multi-agency working.⁵³ Separated young people require protection and intervention to address their health and social needs, and this work should be done within the same framework and to the same standards as for any other young person. Although

age assessment is necessary, it too should be conducted within the same multi-agency safeguarding framework.

It is unfortunate that, to date, neither withdrawal of the UK government's reservation to the UNCRC nor the new statutory responsibility on the immigration authorities to consider the best interests of the child have led to improvements in the process of age assessment. There has been a tendency for immigration and resource issues to cloud the principle of best interests, which should be a primary consideration in decisions affecting children and young people subject to immigration control. The participation of paediatricians has the potential to improve age assessments, both in terms of assessments and in terms of a multidisciplinary process. Paediatricians may restore clarity and ensure that the rights of the individuals concerned are centre-stage. Separated children and young people arriving in the UK are potentially vulnerable and have high levels of health and social need. Statutory health and social care services currently provide assessment of those needs for all separated young people. Age assessment, where necessary, should be an additional component of needs assessment.

These considerations present a challenge to the Royal College of Paediatrics and Child Health, as the custodian of paediatric training programmes in the UK. The college is currently working to develop standardized guidance and protocols for best practice in age assessments and to define appropriate training programmes for increasing the capacity and expertise of doctors. This is urgently needed.

Implications and the future of age assessment

This article has reviewed the medical, statistical, ethical and human rights issues that must be considered when assessing the age of children and young people subject to immigration control. Existing evidence indicates that there is no 'silver bullet' method that will give government and agencies an 'objective' and 'scientific' answer as to the precise chronological age of an individual. Results derived from physical examination and radiographic assessment of developmental age can allow the assessor to conclude whether the individual is physically mature. However, physical maturity may well not correlate with the individual's chronological age.

Individuals will be judged as being physically mature if they satisfy *all* the following criteria:

- height velocity zero i.e. no evidence of growth (within measurement error);
- breast, genitalia and pubic hair development all Tanner stage 5;
- menarche reached (girls);

- bone age Greulich-Pyle grade 19 years (adult pattern);
- dental age Demirjian stage H for all teeth (with the exception of third molars).

Satisfaction of these criteria is consistent with the individual being 18 years or older. However, crucially, it is also consistent with he/she being a child as young as 15 years old. Physical maturity in this sense does not equate to being an adult.

Conversely, signs of immaturity are *any* of the following:

- height velocity greater than zero i.e. evidence of growth;
- breast, genitalia or pubic hair development less than Tanner stage 5;
- before menarche (girls);
- bone age less than Greulich-Pyle grade 19 years (adult pattern);
- dental age less than Demirjian stage H (with the exception of third molars).

An individual who is physically immature by any of these markers is more likely to be under than over 18 years of age, and this is truer for girls than boys.

When judging the age of an individual who is developmentally mature, what matters is their chronological age *at the time they became mature*, and the likely difference between that age and the mean age in the population. This age obviously cannot be observed directly in the individual, but the population mean age can be estimated from a reference sample.

The difference between the two ages is approximately normally distributed and is summarized by the mean and SD, which is typically 1.0–1.5 years depending on which developmental marker is used. It means that, in 95% of cases, the difference between the two ages will be <2 SDs in either direction, i.e. ± 2 or ± 3 years. Take Greulich-Pyle bone age in boys, for example, where the mean chronological age of attaining skeletal maturity is 17.6 years and the SD is 1.3 years (TJC unpublished data). The 95% range of ± 2 SDs is from 15.0 to 20.2 years, so most individuals will have reached maturity by age 20 year or so, while a few of them will have been age 15 years or even younger at that milestone. From the mean and SD, overall 61% of subjects reach skeletal maturity before age 18 years, so individuals are more likely to have been under 18 than over 18 at the time they matured.

This example emphasizes the uncertainty in ascribing adult age to individuals who are developmentally mature. True, such individuals are more likely to be older than younger (simply because maturity is the adult state) but developmental age is usually too imprecise to be

informative—the range of possible ages is just too wide. There is one exception to this—when an individual is skeletally mature and says he is as young as 13 or 14 years, this is well outside the likely age range. Rare endocrine diseases that cause precocious overproduction of sex hormones can substantially advance bone maturity, but in the absence of evidence for an endocrine disorder triggering precocious puberty, it strongly suggests that he or she is older than he or she suggests. But even here, it does not mean that he or she is over 18 years.

If the decision is whether or not the individual is a child (under 18 years), it is expedient whether he or she can be shown to be physically immature. Conversely, if the individual is mature or if the decision to be reached relates to his or her likely date of birth, then the imprecision of the method makes any age predictions highly uncertain.

Human migration in the twenty-first century is unprecedented, creating significant challenges as well as opportunities for receiving countries. As this article has shown, there are no easy answers to the pressing and difficult issue of age assessment, but societies have to decide upon the medical, ethical and human rights standards they are prepared to accept. This demands an open, honest, informed and evidence-based acknowledgement of the limitations and possibilities of current procedures for the assessment of age and the context within which these procedures take place. Age assessment is not a simple technical issue. Contested understandings of age and childhood reflect the politics of age—where representations of childhood are used to support legal and political agendas—and the varied and complex understandings of childhood.⁵⁴ The approach taken towards one group (in this case children and young people subject to immigration control) has implications for the treatment of children and young people more generally. In this context, there must be open public and professional discussion to secure a consensus on what is ethically and morally acceptable in terms of the error margin in assessing age. This article is intended as a contribution to that discussion.

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