# ABSTRACT

**Background:** The health and wellbeing of children are enhanced by judicious use of information gathered from monitoring their growth and development. For the general assessment of growth, individual weight and/or height are the primary tools employed worldwide, including in South Africa. The use of more precise indicators of development, such as skeletal maturation, long bone growth or tooth formation, is extensively used in both human biological research and forensic anthropology. Skeletal data are used in evaluating clinical conditions that result from hormonal imbalances, heritable bone dysplasias and nutritional problems. However, the scarcity of skeletal and dental data on growth and development in foetuses and young children in Southern Africa often necessitates the application of standards and atlases that are derived from older datasets derived primarily from European ancestry populations. The implications of using those non-African standards and atlases are not fully understood, but populational variation is documented. Therefore, population-specific standards to monitor growth, estimate age and compare growth worldwide are required to ensure the accurate assessment of skeletal and dental development.

**Aim:** The aim of this study was to develop a dental formation sequence and document long bone dimensions for a representative sample of urban South African children of African ancestry. These two growth indicators will then be used for the purposes of describing developmental variation and undertaking age estimation for a large paediatric cadaveric research collection. Additionally, it was the aim of this study to digitise and archive the paediatric cadaveric collection for future research activities.

**Materials and methods:** This cross-sectional study used purposeful convenience sampling by comparing computer tomography (CT) scans of the University of the Witwatersrand Paediatric Cadaveric Collection (PCC) to archived medical radiographs from two Gauteng provincial hospitals, as well as, the Wits Dental and Oral Health Centre. Panoramic dental radiographs of 41 living children (16 males, 25 females aged 2.5 - 4.5 years), 665 limb radiographs of 267 living children (145 males, 122 females aged 0 - 4.9 years) and 110 PCC cadavers (62 males, 48 females aged less than 5 years) were included.

Segmentation from the CT scans was accomplished using a 3D volume rendering technique with VG Studio Max 2.2 software. The 3D volume images and 3D surface renderings were then transferred to Avizo software. All radiographs were coded with ImageJ software. The

developmental stage of each tooth was based on the degree of mineralisation where scoring followed the Demirjian 8-stage method adapted for use on the primary dentition. Diaphyseal length and breadth measurements of the limbs were taken from transformed left diaphyses.

Data were analysed using Microsoft Excel software 2016 and IBM SPSS Statistics 25.0 software for Windows. Intra-observer error analysis was done on both dental scoring and limb measurements. Variability in the long bone dimensions was assessed using the level of covariance within each cohort. Comparisons between the living child and cadaver samples were carried out with the Mann-Whitney U test to determine if the samples were from the same population. Statistical significance was inferred at $p<0.05$.

**Results:** The Wits PCC sample was stratified into six age groups based on aggregate diaphyseal lengths of the living children. Outliers in the groups were reassigned to achieve concordance between dental scores and diaphyseal lengths. The 0-0.9 year-old group had the largest representation (33 males, 25 females) while only one male and one female were in the 4-4.99 year-old cohort. Student's t-tests revealed no statistically significant differences in the mean diaphyseal lengths for males and females. There were also no substantial sexual differences in the tooth development stages, which allowed for the pooling of the samples for further analysis.

The sample showed radiographic evidence of mineralisation of all the primary teeth by the 30th week of gestation and mineralisation of the M1 was noted after birth. Visual observation of the dental scores found no more than one stage difference between the PCC and living children, which was considered as not statistically significant. The limbs of the living children were found to be larger than the PCC individuals; however, the Mann-Whitney test demonstrated no substantial difference in the proportion of individuals from either sample below or above the grand median. The non-normal distributions of the two samples show small effect sizes except for the femur and fibula in the 3-3.9 year-olds. These results justified the pooling of the living and PCC samples to generate dental and limb growth charts for South African children of African descent.

All CT scans and segmented bones are now archived with the Human Variation and Identification Research Unit (HVIRU) of the School of Anatomical Sciences, University of the Witwatersrand and available in DICOM format for future research activities.

**Conclusion:** This study showed lower variability in tooth development compared to the limb bone dimensions. The generated data on dental development and limb bone lengths over the

age cohorts not only resulted in the construction of a virtual PCC skeletal collection, but can also be used to better estimate age in southern African children.