Variation in time of emergence of permanent teeth among urban and rural Jordanian school children

Ashraf I. Shaweesh, BDS, PhD, Mahmoud K. Al-Omiri, BDS, PhD, Firas D. Alsoleihat, BDS, PhD.

ABSTRACT

الأهداف: تهدف هذه الدراسة إلى استقصاء التباين في وقت بزوغ الأسنان الدائمة بين أطفال المدارس الأردنيين في الحضر والريف.

الطريقة: أُجريت هذه الدراسة المقطعية خلال الفترة من مارس إلى يونيو 2010م، وشملت طلاب الروضة والمرحلة الابتدائية في مختلف المناطق الحضرية والريفية في الأردن. لقد تم فحص بزوغ الأسنان الدائمة لدى 1900 تلميذ في مدارس المناطق الحضرية، و772 تلميذ في مدارس المناطق الريفية في الفئة العمرية ما بين 5-16 عاماً من كلي الجنسين. ولقد تم حساب متوسط عمر بزوغ الأسنان الدائمة بواسطة تحليل الانحدار بروبيت (Probit).

النتائج: لقد كانت أعمار بزوغ الأسنان الدائمة بشكل عام متقدمة عند الذكور في المدارس الحضرية بالمقارنة مع نظرائهم في المدارس الريفية، غير أن الفروقات بين الفئتين كانت ذات أهمية إحصائية فقط في الناب والضواحك العلوية. وكان التباين بين الإناث في المدارس الحضرية والريفية صغيراً حيث لم تظهر أي فروقات ذات أهمية إحصائية مقارنةً بالذكور.

خاتمة: أثبتت هذه الدراسة سرعة بزوغ الناب العلوي والضواحك العلوية لدى الذكور في المناطق الحضرية مقارنةً بالذكور في المناطق الريفية، ويحتاج السبب المحتمل وراء هذه النتيجة لمزيد من الاستقصاء في المستقبل

Objectives: To investigate the variation in time of permanent tooth emergence between urban and rural Jordanian school children.

Methods: In this observational cross-sectional study, 1900 pupils at urban schools, and 772 at rural schools aged 5-16 years in both genders were examined for emergence of permanent teeth at different urban and rural primary schools and kindergartens in Jordan between March and June 2010. Probit analysis was used to estimate the median age of emergence per permanent tooth.

Results: The emergence ages for most of the permanent teeth were generally advanced in urban schoolboys in contrast to their fellows at rural schools. However, the differences were only statistically significant for the maxillary canine and maxillary premolars. Compared with boys, schoolgirls had smaller variation in permanent tooth emergence across school region, and none of the differences were statistically significant.

Conclusion: Urban schoolboys have accelerated emergence of the maxillary canine and maxillary premolars compared to rural boys. The potential etiology behind this finding needs to be investigated further in the future.

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From the Department of Oral Medicine and Oral Surgery (Shaweesh), Faculty of Dentistry, Jordan University of Science and Technology, Irbid, from the Department of Prosthodontics (Al-Omiri), and from the Department of Conservative Dentistry (Alsoleihat), Faculty of Dentistry, University of Jordan, Amman, Jordan.

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Address correspondence and reprint request to: Dr. Ashraf I. Shaweesh, Department of Oral Medicine and Oral Surgery, Faculty of Dentistry, Jordan University of Science and Technology, PO Box 3030, Irbid 22110, Jordan. Tel. +962 799711847. E-mail: ashrafis@just.edu.jo

A number of biological and environmental factors have been recognized to affect the time of emergence of the permanent teeth. Biological factors are related to the genetically determined biological variation between individuals such as gender difference and ethnic derivation,[1-4] craniofacial growth, and craniofacial morphology.[5] On the other hand, environmental factors are acquired and their presence may predispose to changes in the time and sequence of tooth emergence, especially in the permanent dentition. Examples of some environmental factors known to affect the time and sequence of tooth emergence include fluoride intake,[6] caries,[6-9] premature extraction of predecessors,[10-12] physique,[13-15] nutrition,[13,16] socio-economic class,[17] and secular trends.[1,18] Variation in the time of tooth emergence has been reported

among different categories of people belonging to the same population or ethnic group.[2,17,19-22] Although such variation might be multifactorial, regional distribution[2,17,19] is assumed to be a strong factor as it may alter the surrounding environment. This topic has not received sufficient interest in the literature and has not been studied among the Jordanian children. Therefore, this study focused on investigating the variation in the time of permanent tooth emergence as a result of urban – rural distribution. The aim of this study was to investigate the variation in the time of permanent tooth emergence between urban and rural Jordanian school children, and to present the initial baseline data on permanent tooth emergence specific to the urban and rural communities of the Jordanian population.

Methods. All procedures were conducted in accordance with the Declaration of Helsinki,[23] and carried out with the adequate understanding and written consent of the subjects' parents. The study was approved through the Deanship of Research at Jordan University of Science and Technology (JUST) (Approval number 113/2007). The Ministry of Education also approved the study as it involved collecting data from kindergarten and school children.

The sample consisted of 2672 Jordanian children and adolescents aged 5-16 years selected from different urban and rural kindergartens and primary schools in 3 governorates in Jordan; Irbid (North), Amman (Middle), and Karak (South). The female group consisted of 1432 pupils; 983 from urban schools and 449 from rural schools. The male group was slightly smaller consisting of 1240 pupils; 917 from urban schools and 323 from rural schools. Therefore, the total number of urban school children was 1900 (917 boys and 983 girls), and the total of rural school children was 772 (323 boys and 449 girls). According to the Department of Statistics in Jordan, an agglomeration of people is considered rural when the population is less than 5,000.[24] Therefore, a given school is considered rural when located in an area whose population is less than 5,000 and where most of them have been living there for several generations. All participants were Jordanian citizens of Arab ancestry whose ancestors have been living in Jordan for several generations. They were all healthy and not suffering from any systemic illnesses, hormonal imbalance, or developmental abnormalities. This was verified through checking the consent forms provided by the parents that contained questions on the presence of such conditions in their children. Children with any of the conditions above were excluded. Similarly, using the gender-specific Body Mass Index-for-age growth charts of the Centers for Disease Control and Prevention (CDC): The United States,[25] underweight and obese children with body mass indices under the fifth percentile and over the 95% percentile were excluded. Nevertheless, the selection of participants did not consider socio-economic status or religion.

The sampling was based on multistage clustering. Before drawing the sample, the population of Jordan was classified into northern, middle, and southern regions. Each of the 3 regions in Jordan consists of 4 governorates.[26] The governorates of Irbid, Amman, and Karak were the most populous in their regions,[26] and thus demonstrating the greatest variation according to many of the factors influencing the time of tooth emergence such as the urban-rural distribution, socio-economic class, fluoride intake, caries, untimely loss of predecessor teeth, nutrition, and access to dental care. For this reason, those governorates were chosen to represent the northern, middle, and southern regions.

Each of the selected governorates comprised a number of districts (capital departments) where urban and rural agglomerations exist. The governorates of Irbid, Amman, and Karak consist of 9, 9, and 7 districts.[27] All of the districts within the governorate were included in the sampling process. Within each district, one urban agglomeration, and one rural agglomeration were randomly selected. In all selected urban agglomerations, there were kindergartens, and 2 types of primary schools; governmental and private. However, all selected rural agglomerations contained governmental schools, some contained kindergartens, and none contained private schools.

Within each urban agglomeration, 2 schools per school type (one for boys and one for girls) and one kindergarten were randomly selected. Most of the selected private schools were mixed gender schools. In such situations, only one private school was selected per urban agglomeration. In each rural agglomeration, 2 governmental primary schools (one for boys and one for girls) and a kindergarten (if present) were selected. The distribution of the subjects according to gender, school region and age group is presented in **Table 1**.

Most of the selected schools comprised grades from 1-10, and thus the age of the selected participants ranged from 6-16 years. In each primary school, 5 students were randomly selected per grade. In kindergartens, 5 boys, and 5 girls were selected randomly per each of the 2 levels: Kindergarten 1 and 2.

Information statements, providing information regarding the research and researchers, and pointing out what a potential subject needs to do were sent to the parents of those selected. The information statement contained a consent section that needed to be signed by the subject's parents prior to taking part in the study. When the consent forms were signed and collected by the school administrations, one visit per school was

arranged during which each selected subject (whose parents provided signed written consents) underwent dental examination by one of 4 qualified dentists. Examination of subjects was carried out between March and June 2010.

In the dental examination, the examiners recorded the date of birth of each examinee and collected data regarding the permanent teeth that were emerged at the time of examination. Third molars were excluded. A tooth was considered emerged if any part of it penetrated the oral mucosa. In this respect, the outcome was binary (present/absent). Permanent teeth that were deemed to have been extracted before examination were considered present. On the other hand, teeth believed to be missing (due to agenesis) or impacted were excluded and left uncounted.

The chronological age of each subject was calculated by subtracting the Gregorian date of birth from the Gregorian date of examination. Dates of birth of participants were obtained and confirmed from their birth certificates that were available at school administrations. Then, the age was rounded to the nearest full Gregorian year giving 12 different one-year age groups from 5-16 per gender and school region (urban/rural).

Statistical analysis. Probit analysis (Statistical Package for Social Sciences, SPSS Inc, Chicago Version 16.0) was used to estimate the median age of emergence (expressed as the median potency or the 0.5 probability response level) per tooth along with the fifth and ninety-fifth percentiles (the 0.05 and 0.95 probability response levels). In addition, regional variation (urban versus rural) was entered as a factor (grouping) variable to estimate the relative median potency and its 95% confidence limits across each pair of corresponding teeth between the urban and rural groups of the same gender. At a probability level of 0.05, the difference between 2 groups is considered non-statistically significant when the null value 1.0 is located within the 95% confidence limits of a relative median potency.

Results. In each of the 4 groups (urban males, urban females, rural males, and rural females), when each tooth in one side was matched against the corresponding tooth in the other side, none of the tooth pairs showed statistically significant differences in the median age of emergence at the significance level of 0.05. This was evident from the outcome that the value 1.0 was within the 95% confidence limits of the relative median potency in all of the corresponding tooth pairs. Since there were no statistically significant differences in the median age of emergence of teeth between sides, the data related to each pair of contra-lateral teeth were combined, prepared and imported by the SPSS version 16.0 for Probit analysis.

Table 2 provides the median age of emergence per each of the studied maxillary and mandibular teeth along with the fifth and ninety-fifth percentiles, and standard deviation for urban and rural schoolboys. **Table 3** presents the standards for urban and rural schoolgirls. Also presented in **Table 2 and 3** are the differences in the median age of emergence per tooth between the urban and rural groups of the same gender and the significance of the statistical differences at the probability level (*p*-value) of 0.05.

In general, the ages of emergence of all studied teeth were earlier in females than in males. The average difference between males and females of the same

Table 1 - Distribution of subjects according to gender, school region and age group.

Age group (years)	Urban		Total urban	Rural		Total rural	Total
	Males	Females		Males	Females		
5	121	102	223	7	10	17	240
6	76	92	168	17	27	44	212
7	105	68	173	37	54	91	264
8	97	96	193	45	53	98	291
9	116	87	203	39	50	89	292
10	103	95	198	34	51	85	283
11	128	109	237	38	42	80	317
12	76	91	167	22	50	72	239
13	69	95	164	41	50	91	255
14	15	62	77	24	37	61	138
15	7	49	56	11	17	28	84
16	4	37	41	8	8	16	57
Total	**917**	**983**	**1900**	**323**	**449**	**772**	**2672**

Table 2 - Standards of permanent tooth emergence (in years) for urban and rural schoolboys. The differences (and their statistical significance*) in time of emergence between urban and rural children are also presented.

	Urban males				Rural males					
		Percentile				Percentile				
Tooth	m[a]	5th	95th	sd[b]	m	5th	95th	sd[b]	mU-mR[c]	Sig[d]
Maxillary										
1	7.24	5.95	8.80	0.87	7.09	5.83	8.62	0.85	0.15	NS[e]
2	8.33	6.66	10.42	1.15	8.46	6.76	10.58	1.16	-0.13	NS
3	11.36	9.22	13.99	1.45	11.80	9.58	14.54	1.51	-0.44	SS[f]
4	10.19	7.97	13.02	1.54	10.65	8.34	13.61	1.61	-0.46	SS
5	11.10	8.81	13.99	1.58	11.46	9.10	14.44	1.63	-0.36	SS
6	6.31	5.35	7.45	0.64	6.31	5.35	7.45	0.64	0.00	NS
7	12.72	9.85	16.44	2.01	12.65	9.79	16.35	2.00	0.07	NS
Mandibular										
1	6.47	5.49	7.68	0.67	6.37	5.36	7.56	0.67	0.10	NS
2	7.47	6.15	9.08	0.89	7.38	6.08	8.97	0.88	0.09	NS
3	10.48	8.40	13.07	1.42	10.77	8.62	13.44	1.47	-0.29	NS
4	10.38	8.11	13.29	1.58	10.75	8.40	13.76	1.63	-0.37	NS
5	11.60	9.04	14.88	1.78	11.76	9.17	15.09	1.80	-0.16	NS
6	6.21	5.20	7.40	0.67	6.21	5.21	7.40	0.67	0.00	NS
7	12.18	9.89	15.01	1.56	11.99	9.73	14.77	1.54	0.19	NS

*p-value=0.05, [a]median age of tooth emergence, [b]standard deviation of age of tooth emergence, [c]differences resulting from subtracting the median age of emergence in rural children from that in urban children of the same gender per each tooth, [d]significance of statistical differences, [e]non-statistically significant, [f]statistically significant

Table 3 - Standards of permanent tooth emergence (in years) for urban and rural schoolgirls. The differences (and their statistical significance*) in time of emergence between urban and rural children are also presented.

	Urban females				Rural females					
		Percentile				Percentile				
Tooth	m[a]	5th	95th	sd[b]	m	5th	95th	sd[b]	mU-mR[c]	Sig[d]
Maxillary										
1	7.10	5.90	8.53	0.80	7.00	5.82	8.41	0.79	0.10	NS
2	8.02	6.57	9.80	0.98	8.00	6.55	9.78	0.98	0.02	NS
3	11.03	8.94	13.06	1.26	10.94	8.87	13.49	1.41	0.09	NS
4	9.90	7.91	12.40	1.37	9.99	7.98	12.51	1.38	-0.09	NS
5	10.83	8.69	13.51	1.47	11.03	8.85	13.76	1.50	-0.20	NS
6	6.20	5.00	7.70	0.82	6.00	4.84	7.45	0.80	0.20	NS
7	12.27	10.08	14.93	1.48	12.22	10.04	14.88	1.48	0.05	NS
Mandibular										
1	6.32	5.14	7.77	0.80	6.20	5.05	7.62	0.78	0.12	NS
2	7.37	6.08	8.93	0.87	7.16	5.91	8.69	0.85	0.21	NS
3	9.77	8.01	11.93	1.20	9.72	7.96	11.86	1.19	0.05	NS
4	10.02	8.07	12.42	1.33	9.95	8.02	12.34	1.32	0.07	NS
5	11.04	8.71	13.95	1.60	11.04	8.74	14.00	1.60	0.00	NS
6	6.08	4.83	7.66	0.86	5.89	4.68	7.42	0.84	0.19	NS
7	11.63	9.38	14.43	1.54	11.63	9.39	14.44	1.54	0.00	NS

*p-value=0.05, [a]median age of tooth emergence, [b]standard deviation of age of tooth emergence, [c]differences resulting from subtracting the median age of emergence in rural children from that in urban children of the same gender per each tooth, [d]significance of statistical differences

regional group was 0.32 years for urban children, and 0.49 year for rural children. Since there was a difference in both regional groups between males and females, comparisons between the urban and rural groups were made and presented in **Table 2 and 3** for both genders separately.

All of the mandibular teeth except premolars showed earlier emergence than the corresponding maxillary teeth. This was evident in all of the 4 groups except the rural females. In the latter group, the exception was for the second premolar, although the maxillary precedence in the emergence of that tooth was only 0.03 years. All the differences in the median age of emergence between the urban and rural groups were non-statistically significant except for the maxillary canine and maxillary premolars in males (**Table 2**). For the latter teeth, the differences showed statistical significance. In addition, the differences between the urban and rural groups were generally more evident in males with an average absolute difference of 0.20 years compared with an average absolute difference of only 0.10 years in females.

Generally, the age of emergence was earlier in the urban males than in rural males. However, this was not the case in all of the studied teeth. The teeth that showed earlier emergence were the canines and premolars of both arches along with the maxillary lateral incisor. For the first molar, the age of emergence was the same in the urban and rural males. The rest of the teeth showed very small precedence of emergence in the rural males. For the urban females, though, only the maxillary premolars exhibited earlier emergence. The rest of the teeth either showed exactly the same age of emergence, or a very small delay compared with the rural females.

Except for the rural female group, the sequence of emergence in the maxillary arch was the same in all of the other 3 groups. The earliest tooth to emerge was the first molar, followed by the central incisor, lateral incisor, first premolar, second premolar, canine, and finally the second molar, which was the last to emerge apart from the maxillary third molar. In the rural female group, the emergence of the maxillary canine preceded that of the second premolar.

As for the mandibular arch, the sequence of emergence was different between males and females and the same between the urban and rural groups of the same gender. In males, the earliest tooth to emerge was the first molar followed by the central incisor, the lateral incisor, first premolar, canine, second premolar, and finally the second molar. On the other hand, the sequence in females showed advanced emergence of the canine in contrast to the first premolar.

Discussion. In the present study, the selection of subjects did not consider the potential influence of the varying school type or socio-economic class of children on the timing of permanent tooth emergence. The varying school type is believed to be correlated with the socio-economic class of subjects. Private school children are usually expected to belong to a higher socio-economic class than that of governmental school children. Although such influence of the 2 correlated factors is intended to investigate and present in future work, postponement of that issue presents one limitation in the current study.

The cross-sectional nature of this study presents a number of limitations. The first is that the study only involved clinical examination of subjects without the use of radiographs. In the absence of confirming radiographs, teeth recognized clinically as unerupted (recorded as "absent") or extracted (recorded as "present") might have been congenitally missing or impacted. Likewise, teeth recorded as congenitally missing might have been still unerupted or have been extracted. Nevertheless, such misjudgments are not thought to have biased the statistical outcomes significantly, because the potential effect of these misjudgments is expected to be diluted by the relatively large sample size.

The second limitation of this study is that 4 examiners collected the data on tooth emergence with no intra-examiner or inter-examiner reliability tests carried out. Considering the cross-sectional nature of this study, getting a considerable number of school children re-examined by the same or another examiner at a second occasion might be expensive, time-consuming, disconcerting to those children and more importantly, misleading as new teeth might have emerged in the interim. Besides, the binary type of the examination outcomes and the simple way for recording the findings by any dentist warrants that the possibility of errors is minimal given the large sample. Moreover, the potential effect of an inter-examiner error does not seem to have greatly biased the outcomes because prior to the examination, we conducted a clinical training program for the examiners to ascertain that reliable and reproducible data were collected.

Thirdly, the confounding affect of premature loss of predecessor teeth on the time of emergence of successors could not be investigated in this cross-sectional study. It may be difficult to confirm the premature extraction of deciduous predecessor teeth from a single examination of permanent tooth emergence. Although at the time of examination the observation of delayed or accelerated emergence for a successor tooth might be of help, multiple examination (longitudinal approach) is essential to approximately record the time of loss of the predecessor tooth and the time of emergence of its successor. Available retrospective data may reveal the time of the first event or both events. However, in many

governmental schools especially in the rural areas such data were missing or difficult to retrieve, especially for a student who had received some dental care beyond the school's arrangements.

In a similar approach followed by many previous studies,[28,29] the age groups in this study were formed upon the approximation of the subjects' chronological ages to the nearest full year. As a result of approximation to the nearest full year, some subjects might at worst have been made 6 months older or younger than their chronological ages. Although this appears to have added to the potential errors in this study, given the large number of subjects per age group, a chance of making a subject older is expected to be opposed by an equal chance of making another subject younger, assuming that such chances follow random normal distribution. To test for the effect of approximation to the nearest full year, the median ages of emergence were re-estimated after the ages of the subjects were rounded to the nearest full 6 months. This kind of approximation gave 24 6-month age groups. The results related to 6-month approximation showed insignificant differences when compared to those related to one-year approximation. Thus, it was decided to choose approximation to the nearest full year in order to increase the number of subjects per age group and thus increase the power of the study.

The finding that there were no differences in permanent tooth emergence across sides is consistent with the findings of many studies reporting different populations.[1-4] In addition, except for premolars, all mandibular teeth generally preceded their maxillary opponents in emergence. However, the time of emergence of premolars showed no mandibular arch precedence. Generally, the urban and rural school children showed no difference in terms of emergence symmetry across side and inter-maxillary precedence of emergence.

On the other hand, the finding that all permanent teeth in females emerged earlier than in males agrees with many studies conducted on different populations.[1-4] However, the amount of difference in the findings between males and females was slightly greater in the rural groups.

As for the sequence of emergence, it was the same between the urban and rural males and slightly different between the urban and rural females. The difference in females was because the rural females have their maxillary canine erupting before the maxillary second premolar.

Concerning the difference in the time of permanent tooth emergence between the urban and rural school children, females of both regional groups generally had similar findings. In contrast, urban males exhibited significant precedence in the emergence of the maxillary canine and maxillary premolars. To interpret the latter finding, it is important to be aware of the varying eating behavior between the urban and rural schoolboys. In the absence of studies on the association between rural standards of living and nutrition of children in Jordan, we expect that urban schoolboys generally eat more cariogenic food than their fellows at rural schools, who usually consume more vegetables. This leads to earlier development of caries in urban schoolboys and consequently earlier loss of predecessors. As it has been reported in many previous studies, premature loss of deciduous molars accelerates the emergence of their successors.[10-12,30] On the other hand, the finding that no significant differences were evident among urban and rural females may be because Jordanian girls are usually more indoor-living compared to boys putting their eating behavior and tooth brushing under more parental supervision.

This study investigates the effect of urbanization on the timing and sequence of permanent tooth emergence among Jordanian school children. It also investigates such an effect among children of the neighboring Arab countries. The effect of urbanization on the time of emergence of permanent teeth has been studied among western European communities.[17] There has been lack of agreement as to the reported results. While some studies found accelerated emergence among rural children relative to urban children,[17] others stated that the emergence was accelerated among urban children.[31] A third group found that there was no regional variation.[2,32] While a few studies on European communities have been published,[2,17,31,32] in the absence of similar studies on Arabs and neighboring countries, the detailed findings of this study on the effect of urbanization on tooth emergence could not be analyzed in contrast to those of studies on European children. This is because we assume that the impact of urbanization in the developing communities, and particularly Arabs, is different from that in the developed European nations. The effect of urbanization on improving life style, socio-economic status, and nutrition, is supposed to be more evident in a developing country like Jordan than in the developed western European countries. We expect that the lower socio-economic class and the more natural style of living of Jordanian rural children may be associated with less consumption of cariogenic foods like candies and chocolates and more eating of fresh vegetables that can be easily collected from the backyard of any rural house in Jordan. This may be linked to the earlier development of extensive caries and premature loss of deciduous molars among urban boys, leading

to accelerated emergence of premolars, which was the finding of this study. Nevertheless, what we provided on the potential etiology of the accelerated emergence of premolars in urban schoolboys remains just an assumption rather than a conclusion. Therefore, we suggest that future research should further investigate possible associations.

In conclusion, this study presented the regional variation in chronological standards of permanent tooth emergence between urban and rural Jordanian school children. There is dissimilarity between urban and rural school children in the amount of difference in the same gender, being greater between urban and rural schoolboys. Urban schoolboys have accelerated emergence of the maxillary canine and maxillary premolars compared with rural boys. The potential etiology behind this finding needs further investigation.

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