Micronutrient Deficiencies Among Children May Be Endemic in Underprivileged Areas in Jordan

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Abstract

Objectives: In late 2002, this Ministry of Education sponsored a survey aimed at assessing nutrition and growth statuses of young school children in underprivileged areas in Jordan. It aimed to substantiate the drastic findings of a preceding survey and to highlight other aspects of the problem, including the dietary consumption patterns.

Methods: This was a cross-sectional study of 468 school children from 43 villages, affiliated to eight disadvantaged areas of Jordan. All these were eligible recipients of the School Snack Service (SSS) program. Subjects were selected randomly from a sample originally drawn by Jordan Department of Statistics, DOS. Randomly selected school children aged 5.5 to 10.0 years were representing the first three elementary grades. The HPLC technique was employed in measuring concentrations of serum retinol (SRC) and α-tocopherol. The measurements of the anthropometric indicators and hemoglobin and serum ferritin levels were carried out. Relevant dietary information was collected. Immediately afterwards, students began receiving the SSS for another full scholastic year.

Results: Approximated average prevalence rates were for stunting 15 %, anemia (hemoglobin concentration < 110 g/L) 19.9 %, and subclinical VAD (SRC< 200 µg/L), 32.9 %. Proportion of children at risk of becoming deficient (SRC <300 but =>200 µg/L) was 58.3 %. Serum ferritin value was 18.3 (SD± 8.8) µg/L; unexpectedly, ferritin had significant correlation with vitamin A status but not with hemoglobin level. Vitamin A intakes were seemingly inadequate, as suggested by the laboratory assessment data. However, dietary data failed to lead to the same conclusion.

Conclusion: Stunting dominates the growth profile of children in primary schools of underdeveloped areas. Associated with vitamin E deficiency and anemia, VAD strongly suggests the existence of a severe grade of nutritional deprivation which pushes toward endemicity of the nutritional problem. Based on this conclusion, a cascade of interventional nutrition programs followed. In 2003 and 2004 two Royal Philanthropies were issued and led to the emergence of two pioneering interventional programs: the 'multi-vitamin tablet' for all schools and the 'multi-micronutrient' - fortified biscuits for the poor school children. The latest in sequence has been the year 2006, as it depended the implementation of the second "Wheat Flour Fortification" program, the fortificants in which have included nine micronutrients which are: vitamin A, iron, folic acid, and zinc and five major B-vitamins (B1, B2, B3, B6, and B12).

Keywords: Vitamin A (VA), serum retinol concentration (SRC), vitamin A deficiency (VAD), hemoglobin (Hb), ferritin (Fer), stunting.

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Introduction

The nutritional health problems of school-age child have attracted in recent years the attention of decision makers in Jordan. This interest evolved from the interaction of two factors. The first was the general feeling that the academic performance of schools and the achievements of students, specifically in "underprivileged" areas of the Kingdom, were seen deteriorating. The second factor has been the array of international scientific data which suggest that school-age children may not in fact be healthier than younger children. From one aspect, there has been evidence on the critical link between learning and school children's health and nutrition, suggesting a substantial potential gain in educational effectiveness from improving children's nutrition and health. [1] From another, a wide range of research works focusing on human somatic growth underscore it as the key indicator of child health and development. [2] From this perspective, 'stunting' and 'wasting' are mostly renowned today as reflections of 'suboptimal nutrition' states, that stem from either protein-energy-malnutrition, PEM, or micronutrient - deficiencies. Stunting, as the famous indicator of long term nutritional deprivation, has been attracting more attention in scientific research due to the positive association between linear-growth on one side and child mortality [3, 4] and developmental achievement on another. [5] Because socioeconomic environments may considerably influence child growth velocity, [6] different well-oriented communities are always enthusiastic to adopt the principle of conducting anthropometric assessments on children. [2, 7, 8] After global emphasis on nutritional components in child growth and development was activated, [9, 10] this gave more momentum to the local efforts in Jordan. [11] Early research in the Middle East implicated micronutrients' inadequacies at community levels [12, 13] as causes of stunting. In Jordan, no similar focus on the growth problem had ever been done. [14-19] Researching in the years of 1990s [20-23] ended with the Ministry of Education, MOE, launching its pioneering SSS (School Snack Service) program for the young school children in deprived regions in the Kingdom.

Recognizing the scientific reports on the essentiality of vitamin A as a driving force in children's pubertal growth and sexual maturation, [24] an interventional survey study was conducted to assess the SSS impact on recipients' health. The survey highlighted subclinical (non-ocular) vitamin A deficiency, VAD, and stunting as being two public health problems in the poverty pockets in Jordan. [25] To verify such drastic findings, the current study was launched in the same "underprivileged" governorates, but in different villages, which are characterized by being relatively more remote from the central towns.

Materials and Methods

Research Assistance: Research team included 22 research assistants. All were university graduates and representing the public health nutrition, nursing, and biotechnology disciplines. Employment was specifically intended for conducting the field and laboratory works.

Sampling: 43 villages representing eight of the study underdeveloped locations (areas) were selected randomly with assistance from the General Department of Statistics. The eight locations were the governorates and districts of: Aqaba, Karak-Lajoon, Maan, Tafeelah, DairAlla, South Shunah, Al-Saafi, and Mafraq and North Badia. Central towns were excluded. Sampling involved students who were attending the classes and thus assumed by parents as healthy. This meant to eliminate possible role of illness in affecting the biochemical and hematological parameters. At the onset of field work, as the SSS recipients were in total of 16,000 primary school children, random selection of a sample size of 5 % of total was seen adequate due to logistic limitations. The recruited subjects were children aged 66 -120 months, who were attending schools' first three elementary grades. The total reached 468 children.

Data Collection: Data collection included anthropometric, laboratory, and basic dietary data. Anthropometry standard methodology was implemented; [26-28] the linear growth measurements- standardization procedure was

applied in the field at an earlier stage. Blood samples were collected. The study -laboratory tests were hematological (hemoglobin and hematocrit) and biochemical (serum retinol concentration, SRC, serum α-tocopherol concentration, and serum ferritin concentration). Testing of serum retinol was by the HPLC technique. [29] Dietary information, using a one-page questionnaire, focused only on rough calculation of nutritional intakes of a sub-sample of students. Respondents to the questionnaire were five mothers of students from each of the eight locations, making a total of 40 subjects.

Data Analysis: Derivation of anthropometric indices and statistics on stunting and wasting were computed by using the "CDC / WHO-Anthro" software and NCHS-child growth standards. [30, 31] Other analyses were run using the Statistical Package for Social Studies (SPSS), Version 4. The fundamental cut-off used to identify malnutrition and deficient growth was the "z score value being less than -2".

Results

A summary of the nutritional variables and abbreviations with selected statistics is outlined in table (1). In the rest of the tables, however, only those variables which showed considerable variation under different circumstances will be highlighted. The correlations between measured and derived variables were identified. Vitamin A correlated with hemoglobin ($r= 0.09$; $p< 0.6$) and ferritin ($r=0.11$; $p< 0.02$); VA, however, correlated very strongly with α-tocopherol ($r=0.32$; $p <0.001$). Anthropometry as shown in table (2) was at low levels. Prevalence of wasting (deficient relative ponderal growth) was 4.5 %, nearly around the normal levels. Except for its moderate prevalence among children from the Maan remote villages (11.1%), wasting was not found to be a problem in the study regions, with the extreme prevalence being 7.1 % in the Dair-Alla schools. Clearly, there was gender-related differences regarding prevalence of wasting (6.9 % for males vs. 2.9 % for females; $p< 0.05$); no apparent justification or reasoning could be readily identified for such a finding.

Table (1): Descriptive Listing of Study Nutritional Variables (n*=468).

Variables and Abbreviations		Mean	SD	Min	Max
SRC	**Serum Retinol Concentration_µg/L**	221.51	55.56	64	441
Toco	**Serum α-Tocopherol Concentration_mg/L**	8.16	1.79	4.3	14.2
HB	**Hemoglobin concentration_g/dl**	11.76	1.03	6.8	14.5
PCV	**Hematocrit_%**	35.04	3.58	23	45
MUAC	**Mid Upper-Arm Circumference_cm**	16.34	1.39	10.0	22.4
SFT	**Triceps-Skinfold Thickness_mm**	6.96	1.91	4.0	15.0
FER	**Serum Ferritin_ng/ml**	18.29	8.48	6.7	51.9
MCHC	**Mean Corpuscular Hemoglobin Conc._%**	33.74	3.03	26	48
HAZ	**Linear Growth_z score**	-1.10	.90	-3.59	1.68
WHZ	**Relative ponderal growth_z score**	-.52	.94	-3.19	2.77
BMI	**Body Mass Index_kg/sq.m.**	14.64	1.31	11.2	19.6

Table (2): Low Anthropometry [Prevalence of Malnutrition (Z score < -2)].

Malnutrition	Age/months	Males		Females			Both Genders	
		n*	%**	n*	%**	P***	N*	%
	60 - 83	115	14.78	128	7.81		243	11.11
Stunting	84 - 119	74	21.62	151	18.54		225	19.56
Height/Age	**All Ages**	**189**	**17.46**	**279**	**13.62**	**0.26**	**468**	**15.17**
	60 - 83	115	4.35	128	3.13		243	3.70
Wasting	84 - 119	74	10.81	151	2.65		225	5.33
Weight/height	**All Ages**	**189**	**6.88**	**279**	**2.87**	**0.04**	**468**	**4.49**

****n: number of children in sample;** %: proportion of affected children;***
******: p: significance level in comparing males with females.***

Stunting was at a 15.7 % level. Mean values of the leading nutritional indicators and other statistics in the eight study areas are shown in table (3). However, prevalence rates of nutritional problems at the governorate or district level are summarized in table (4). The special feature of table 4 is that it shows clearly the high prevalence rates of VAD in almost all of the study poor areas. Except for Tafeelah villages showing a considerably low value (9.1 %), VAD prevalence ranged from 21.4 in DairAlla to nearly 40% in Mafraq and North Badia area. From another aspect, table (4) shows that moderate anemia prevalence reached a peak of 25 % in DairAlla and its lowest level was (17.2%) in the villages of Aqaba and South Shunah. In South Shunah also, maximum prevalence rate of stunting was detected. In light of previous reports, [20, 21] the factor that could have contributed to the stunting problem was assumed to rest on household food supply and consumption. Dietary assessment of school children was done by the factorial method, which uses food composition tables (FCT) in nutrient calculation. [32, 33] Dietary questionnaire which took the format of a 24-hour diary (record) technique, produced estimates of means of dietary intakes compared with the RDAs reference values. It was shown that as percentages of the RDA, children's dietary intakes with respect to energy, protein, vitamin A, calcium and iron averaged 90%, 85%, 80%, 70%, and 55%, respectively. Supply of each of these supplies was anticipated to increase by 25% of RDAs as children started benefiting from the SSS program. Apparently, most of the protein supplies came from basic cereal foods (bread and rice) and to a less extent from powdered cow milk. By setting a cut-off point for adequacy of supply at the level of 75% of RDA, only iron intakes (crude average of 55 %) were deemed inadequate.

Investigation of the hematological conditions revealed that anemia was common in the young school children (table 4). Mean hemoglobin concentration was 118 g/L (tables 2, 3). Using 'Hb < 110 g/L' cut-off, and according to the ACC/SCN (Administrative Committee on Coordination - Subcommittee on Nutrition) classification, [34] 19.9 % of the investigated children had anemia. When hemoglobin concentration cut-off point 120 g/L was used, 53 % of children were found to be anemic (table 4). Severe anemia in the studied sample of children was not detected.

Mean SRC was 222 (SD ± 56) µg/L (table 3). More than 90% of the forty mothers reported frequency of vegetable foods availability and consumption to be >=5 days/week. Proportions of children having subclinical VAD (SRC< 200 µg/L), or being at risk of becoming deficient (SRC 200 to 299 µg/L) were 32.9% and 58.3 %, respectively (table 4). Serum α-tocopherol concentration was found to be higher in female (8.41 mg/L) compared to the male children (7.87 %). Apart from that, no significant gender-related differences could be detected. Table (5) demonstrates the extent of power inherent in each nutritional variable that exert influence on other variables. Of the significant influences discovered were those of: vitamin A status on levels of hemoglobin, serum vitamin E, serum ferritin, and on triceps skinfold thickness; vitamin E status on levels of serum vitamin A and on skinfold thickness, and ferritin status on the level of vitamin A.

Table (3): Mean Values of Major Parameters by Study Sites.

Variable & Governorate	*Mean*	*SD*	*min.*	*max.*	*(n)*
VA : Serum Retinol(µg/L)					
All regions	*222*	*56*	*64*	*441*	*468*
Aqaba villages	*226*	*55*	*107*	*359*	*58*
Karak/Lajoon	*221*	*54*	*127*	*341*	*28*
Maan villages	*225*	*55*	*114*	*360*	*27*
Tafeelah villages	*290*	*67*	*194*	*441*	*22*
DairAlla villages	*249*	*67*	*122*	*370*	*28*
South Shunah villages	*222*	*45*	*139*	*340*	*29*
Mafraq/ North Badia	*209*	*48*	*77*	*325*	*140*
Al-Saafi	*215*	*52*	*64*	*348*	*136*
HB : Hemoglobin concentration(g/dL)					
All regions	*11.8*	*1.0*	*6.8*	*14.5*	*468*
Aqaba villages	*11.9*	*1.1*	*10.0*	*14.5*	*58*
Karak/Lajoon	*11.4*	*1.2*	*6.8*	*12.9*	*28*
Maan villages	*11.9*	*.9*	*10.2*	*13.2*	*27*
Tafeelah villages	*11.5*	*.8*	*9.6*	*12.5*	*22*
DairAlla villages	*11.5*	*1.0*	*9.5*	*13.7*	*28*
South Shunah villages	*12.0*	*1.0*	*10.5*	*14.2*	*29*
Mafraq/ North Badia	*11.8*	*1.0*	*9.2*	*14.1*	*140*
Al-Saafi	*11.7*	*1.1*	*9.0*	*13.8*	*136*

Table (4): Prevalence rates of major nutritional deficits among children in the different study areas*.

Vitamin A Category_ µg/L	*Freq %*	*Hemoglobin Category_g/L*	*Freq %*	*Linear Growth Category_cen'le*	*Freq %*	*n***
All Locations						*468*
<200 (deficient)	*32.9*	*<11 (Anemic)*	*19.9*	*Stunted*	*15.2*	
200-299	*58.3*	*11-11.9*	*33.1*	*5th -49th centile*	*74.4*	
=> 300	*8.7*	*>= 12*	*47.0*	*=> 50th centile*	*10.5*	
Aqaba						*58*
<200 (deficient)	*29.3*	*<11 (Anemic)*	*17.2*	*Stunted*	*13.8*	
200-299	*63.8*	*11-11.9*	*37.9*	*5th -49th centile*	*77.6*	
=> 300	*6.9*	*>= 12*	*44.8*	*=> 50th centile*	*8.6*	
Karak						*28*
<200 (deficient)	*32.1*	*<11 (Anemic)*	*17.9*	*Stunted*	*17.9*	
200-299	*60.7*	*11-11.9*	*53.6*	*5th -49th centile*	*71.4*	
300-399	*7.1*	*>= 12*	*28.6*	*=> 50th centile*	*10.7*	
Maan						*27*
<200 (deficient)	*25.9*	*<11 (Anemic)*	*18.5*	*Stunted*	*18.5*	
200-299	*66.7*	*11-11.9*	*14.8*	*5th -49th centile*	*74.1*	
=> 300	*7.4*	*>= 12*	*66.7*	*=> 50th centile*	*7.4*	
Tafeelah						*22*
<200 (deficient)	*9.1*	*<11 (Anemic)*	*18.2*	*Stunted*	*9.1*	
200-299	*50.0*	*11-11.9*	*45.5*	*5th -49th centile*	*63.6*	
=> 300	*40.9*	*>= 12*	*36.4*	*=> 50th centile*	*27.3*	
DairAlla						*28*
<200 (deficient)	*21.4*	*<11 (Anemic)*	*25.0*	*Stunted*	*10.7*	
200-299	*50.0*	*11-11.9*	*46.4*	*5th -49th centile*	*67.9*	
=> 300	*28.6*	*>= 12*	*28.6*	*=> 50th centile*	*21.4*	

South Shunah						*29*
<200 (deficient)	*34.5*	*<11 (Anemic)*	*17.2*	*Stunted*	*20.7*	
200-299	*58.6*	*11-11.9*	*31.0*	*5^{th} -49^{th} centile*	*65.5*	
=> 300	*6.9*	*>= 12*	*51.7*	*=> 50^{th} centile*	*13.8*	
Mafraq and North Badia						*140*
<200 (deficient)	*39.3*	*<11 (Anemic)*	*20.0*	*Stunted*	*19.3*	
200-299	*57.1*	*11-11.9*	*28.6*	*5^{th} -49^{th} centile*	*75.0*	
=> 300	*3.6*	*>= 12*	*51.4*	*=> 50^{th} centile*	*5.7*	
AlSafi						*136*
<200 (deficient)	*35.3*	*<11 (Anemic)*	*21.3*	*Stunted*	*11.0*	
200-299	*58.1*	*11-11.9*	*30.9*	*5^{th} -49^{th} centile*	*77.9*	
300-399	*6.6*	*>= 12*	*47.8*	*=> 50^{th} centile*	*11.0*	

**** prevalence rates of nutritional deficits in bold figures;***
*****n: sample size***

Table (5): Variables found to be influenced by different nutritional statuses (independent t-test).

Parameters	***n***	***Mean***	***SD***	***P§***
As determined by vitamin A status*				
HB : Hemoglobin concentration_g/dL				
*Deficient**	*154*	*11.62*	*1.075*	*.044*
Normal	*314*	*11.83*	*1.004*	
TOCO: serum α-tocopherol_mg/L				
*Deficient**	*124*	*7.61*	*1.631*	*.000*
Normal	*230*	*8.46*	*1.806*	
Fer: serum Ferritin_µg/L				
*Deficient**	*154*	*17.02*	*7.71*	*.02*
Normal	*314*	*18.92*	*8.77*	
SFT: triceps-Skinfold Thickness-mm				
*Deficient**	*154*	*6.64*	*1.631*	*.007*
Normal	*313*	*7.12*	*2.021*	
As determined by vitamin E status**				
VA : serum Retinol_µg/L				
*Low Status***	*303*	*213.17*	*51.923*	*.000*
Normal	*165*	*236.82*	*58.842*	
SFT : triceps-Skinfold Thickness-mm				
*Low Status***	*303*	*6.69*	*1.826*	*.000*
Normal	*164*	*7.45*	*1.976*	
As determined by status of serum ferritin level***				
VA : serum Retinol_µg/L				
*Deficient****	*137*	*208.58*	*56.732*	*.001*
Normal	*331*	*226.86*	*54.264*	

**** Deficient :(VA <200 µg/L) ; Normal :(VA >=200 µg/L)***
***** Vitamin E Status: Low Status (VE <10 mg/L); Normal(VE >=10 mg/L)***
****** Iron deficient (low ferritin if serum ferritin <12 µg/L)***
§ p: significance level

Discussion

The results have indicated that stunting dominated the growth profile of young children in primary schools of underdeveloped areas in the Kingdom. The finding of low prevalence of wasting conforms to the statistics from developing countries reported in the `WHO-Global Nutritional Status' summaries. [35] However, and although the growth deficits could be attributed to nutritional inadequacies early in life, detection of the widespread subclinical vitamin A deficiency, VAD, could have drawn attention to it as the primary cause. With the results referring to strong presence of vitamin E deficiency, risk of a negative impact on child neurologic development [36, 37] could not be ignored. As it was associated with vitamin E deficiency and anemia, VAD could strongly suggest the existence of a severe grade of nutritional deprivation which pushed toward the problem becoming endemic. Skewness, which serum retinol concentration distribution curve exhibited, might be used as an evidence that children in poor areas could be battered by serious interactive types of nutritional deprivation. Evidence on the dietary etiology of the problem could be recognized by the rapid and significant impact of vitamin A capsules distribution on the serum retinol profile of recipients. [25] Such immediate elevation of SRC and other parameters would definitely exclude the presence of defective intestinal absorption.

With respect to the high prevalence of mild to moderate nutritional anemia problem, that could be attributed to the limited and infrequent consumption of foods from animal sources. However, the problem seemed to be multifactorial. Such a conclusion was based on the fact that the depression of serum ferritin levels was not so distinguishable. Anticipating the promotive impact from the previously served snack-biscuits iron and other SSS components, it would be probable that those extra supplies had enhanced the erythropoietic mechanisms on the side of iron deficient children.

In the light of the socioeconomic profile of the studied population, the sweeping survey findings had raised more than one alarm flag. Because school age is customarily considered under lower threat of nutritional disorders than younger ages, [1] the study results indicated a possibility of perceiving very much worse conditions among preschool - population of children. Therefore, and on basis of findings and conclusions of this study, a cascade of official interventional nutrition programs followed. Two Royal Philanthropies, issued in 2003 and 2004, led to the emergence of pioneering interventional approaches: the 'multi-vitamin tablet' for all schools and the 'multi-micronutrient' - fortified biscuits for the poor school children. The latest interventional measure has been Jordan's implementation of the second "Wheat Flour Fortification" program in 2006; the premix includes nine micronutrients, which are: vitamin A, iron, folic acid, zinc and five major B-vitamins (B1, B2, B3, B6, and B12). Periodic repetition of this survey for monitoring status in the same underprivileged areas is highly warranted.

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العوز الغذائي عند الأطفال في المناطق الأقل حظاً في الأردن

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الملخص

الاهداف: هدفت هذه الدراسة المسحية الميدانية التي أجريت في شهر أيلول عام 2002 والمدعومة من قبل وزارة التربية والتعليم إلى تقييم حالة النمو والتغذية عند صغار تلاميذ المدارس في المناطق الأقل حظاً، وذلك لتمحيص نتائج مسح سابق للمدارس الابتدائية هناك والتي أشارت إلى شيوع مشكلة العوز الغذائي فيها. تضمنت الأهداف إلقاء ضوء على أنماط الاستهلاك الغذائية في تلك المناطق.

الطريقة: أجريت الدراسة على عينة من 468 تلميذاً ملتحقين بالصفوف الثلاثة الأولى ل 43 مدرسة ابتدائية لم تدرس سابقاً، تقع جميعها في قرى نائية تتبع ثمانياً من محافظات وألوية المملكة الأقل حظاً، والتي كان يجري فيها تطبيق برنامج الوجبة المدرسية الخفيفة التي أطلقت عام 1999. تضمنت الدراسة عمل القياسات الجسمانية للتلاميذ وإجراء الفحوصات المخبرية والتقييم الغذائي.

النتائج: بلغت معدلات انتشار قصر القامة 15 %، فقر الدم 19.9 %، وعوز فيتامين أ 32.9 %. اما نسبة من هم على حافة الإصابة بعوز فيتامين أ فكانت 58.3 %. وصل معدل تركيز الفيرتين في مصل الدم 18.3 %، وتبين أن هذا المستوى مرتبط بمستوى فيتامين أ ولكنه ضعيف الارتباط بتركيز خضاب الدم. أشارت البيانات إلى أن تدني المتناول الغذائي هوسبب ارتفاع انتشار عوز فيتامين أ .

خاتمة: ثبت ارتفاع انتشار عوز فيتامين أ كمؤشر قوي على عمق الحرمان التغذوي الذي يعم مجتمع أطفال مناطق المملكة الأقل نصيباً من التنمية. ترتب على هذا الكشف تداعيات اجرائية تدخلية جمة.

فبناءً على نتائج هذه الدراسة أتت المكرمة الملكية الشهيرة الأولى التي دعت لتوزيع حبوب الفيتامينات والمعادن على طلبة مدارس المملكة كافة. ثم لحقت بها المكرمة الملكية الثانية بانتاج البسكويت المدعم بالمغذيات الدقيقة في معامل القوات المسلحة لتوزيعه على تلاميذ المناطق المحرومة. وأعقب كل ذلك استبدال حبة الفيتامين ببرنامج تدعيم دقيق القمح بتسع من المغذيات الدقيقة. ومن الأهمية التوصية بتكرار هذه الدراسة في المناطق المحرومة بصورة دورية.

الكلمات الدالة: فيتامين أ، تركيز الفيرتين في مصل الدم، عوز فيتامين أ، هيموغلوبين الدم، قصر القامة.