Journal of Refugee & Global Health

Original Research

Vitamin Deficiencies Among Resettled Refugees in Buffalo, NY

Tyler B. Evans[1], Myron Glick[2]*

Abstract

Background: Vitamin deficiency in the developing world is a considerable public health issue that is often overlooked. Refugees are some of the most vulnerable populations, since they rely almost exclusively on the nutrition provided by refugee camps. Buffalo, NY resettles the fourth largest number of refugees per capita among cities in the United States (US).

Objective: We examined the prevalence of vitamin A, B2, B12, and D deficiencies among refugees who had been recently resettled to Buffalo, NY and referred to our practice for assessment. Our exploratory objective was to examine potential differences in the prevalence of vitamin deficiencies among those living in specific refugee camps.

Methods: *Study Design:* Retrospective chart review. *Study Population:* Refugees between the ages of 2 and 75 and resettled in Buffalo between December 2012 and March 2014 who were registered patients at our practice (n=250). *Independent Variables:* Age, gender, country of origin, country of refugee camp refugee, length of time in US prior to medical evaluation, length of time in refugee camp. *Dependent Variables:* % of deficiencies among vitamin A, B2, B12 and D levels. *Data Analysis: Fisher Exact Test*; ANOVA.

Results: There was only one reported case of vitamin A deficiency (0.45%, p=0.37) and only 6 cases of vitamin B2 deficiency (3.4%, p=0.87). Conversely, vitamin B12 and D were deficient in 37.2% (p<0.0001) and 58.9% (p<0.0001) of samples, respectively.

Discussion: There are concerning deficiencies noted for vitamin B12 and D levels among refugees resettled in Buffalo, NY. There was also significant variation in the prevalence of vitamin B12 and D deficiency between countries of refuge. These analyses suggest that vitamin B12 and D deficiency is a considerable issue in refugees resettled in NYS and should be addressed by local clinicians involved in the post-resettlement care of these populations.

DOI: 10.18297/rgh/vol2/iss2/1
Submitted Date: December 29, 2018
Accepted Date: April 22,2019
Website: https://ir.library.louisville.edu/rgh
Affiliations:
[1]University of Southern California
[2]Jericho Road Community Health Center

Recommended Citation:
Evans, Tyler B. and Glick, Myron MD (2019) "Vitamin deficiencies among resettled refugees in Buffalo, NY," *Journal of Refugee & Global Health*: Vol. 2 : Iss. 2 , Article 1.

Background

Malnutrition among refugees is a multifaceted problem with devastating consequences. It is most often perceived (and dealt with) as a deficiency of macronutrients (e.g. carbohydrates, proteins and fats). However, micronutrients are often overlooked. Micronutrients are required trace minerals, including elements (e.g. iron, zinc, selenium) and organic vitamins. Children in developmental stages are most at risk. (1)

Numerous studies have shown that the levels of micronutrients among resettled refugees are often below the optimal range. While the etiologies are certainly multifactorial, these observations are likely compounded by a lack of adequate micronutrient fortification in food rations and aid supplies during refugees at various refugee camps worldwide. (2, 3)

According to the US Department of State Department of Population, Refugees and Migration, New York (NY) state has the 3rd highest rate of refugee arrivals (4), Buffalo, NY is now the 4th largest US recipient of refugees per capita. (5) Jericho Road Family Practice (JRFP), located in Buffalo, NY, provides post-resettlement and supplementary medical services that impact over 2,000 refugees per year (including >600 new refugees seen annually). (4)

Prior Evidence of Vitamin Deficiency in Refugee Populations

Vitamin A:
According to the World Health Organization (WHO), deficiencies in vitamin A ranks among the top ten leading causes of death through disease in developing countries. (2, 6) As a result, vitamin A is supplemented in many foods distributed in refugee camps, and recorded levels have increasingly normalized over the course of the past 20 years. (6) However, disparities still remain. As the WHO classifies a prevalence of vitamin A deficiency exceeding 20% as a "substantial public

*__Correspondence To:__
Tyler B. Evans, MD, MS, MPH, DTM&H
Associate Professor, Leonard Davis School of Gerontology, University of Southern California
Los Angeles, CA 90089
Email: tbe_950@usc.edu

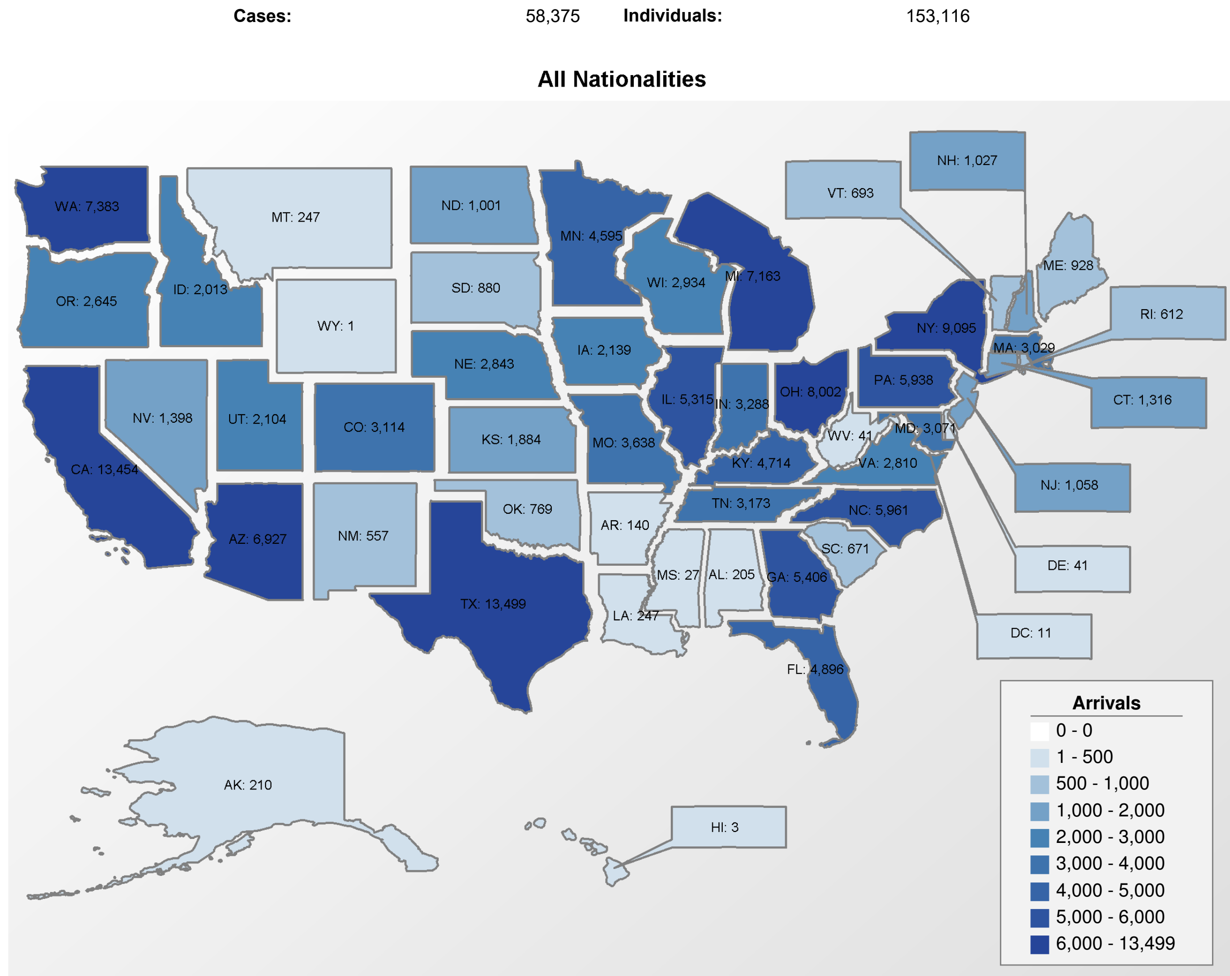

Figure 1 Geographic mapping of refugee arrivals in the USA by state, 2016-2018. http://www.wrapsnet.org/admissions-and-arrivals/
Data extracted from the Worldwide Refugee Admissions Processing System (WRAPS).
RPC/rpt_WebArrivalsReports/Map - Arrivals by State and Nationality
Report Run Date: 4/22/2019 1:54:56 PM

health problem", these figures should provide a call to action. (6)

Vitamin B2:
One study reported that 85.5% of Bhutanese adolescents [n=463] were vitamin B2 deficient. (9) Notably, based upon its rarity as well as its association with other B-vitamin deficiencies, it was posited that B2 deficiency might serve as a harbinger for studying such deficiencies in food aid-dependent populations. (9)

Vitamin B12:
Refugees from countries with compromised food supplies, and particularly those where intake of animal source foods (ASF) are limited, are at risk of Vitamin B12 deficiency. (1) There is considerable variability in refugee groups with South Asians (namely Bhutanese) reporting some of the highest prevalence, presumably related to access to ASF. (11) Direct measurement of B12 is often found to be insensitive and other biomarkers (e.g., methylmalonic acid, MMA) have been recently introduced as more sensitive measures to diagnose functional deficiency, as will be discussed below. (12, 13)

Vitamin D:
Vitamin D deficiency among refugee populations have multifactorial causes, as they are often from volatile sociopolitical contexts often entrenched in conflict. (14) Consequently, theories of protracted hiding, compounded by dietary limitations have been reported. (14) Other studies have cited protective or religious clothing (often associated with Islamic faith), and a longer duration of residence in camps prior to resettlement to be associated with deficiency. (15, 16, 18) Numerous studies in refugee populations have reported a wide variance of deficiency from 13% to 98%, with Middle Eastern and East African groups reported with the highest prevalence. (14-17)

Study objectives:
1. The primary objective was to examine the prevalence of vitamin A, B2 (riboflavin), B12 (cyanocobalamin), and D deficiencies among refugees who have been recently resettled to Buffalo, NY.
2. A secondary objective was to explore potential differences in the prevalence of vitamin deficiencies by refugee in specific refugee camps predicated on the hypothesis that lack of micronutrient fortification in refugee camps is variable and a significant risk factor for deficiency.

Methods

Study Design:
We used a cross-sectional design to assess selected vitamin deficiencies among refugees evaluated at JRFP in Buffalo, NY.

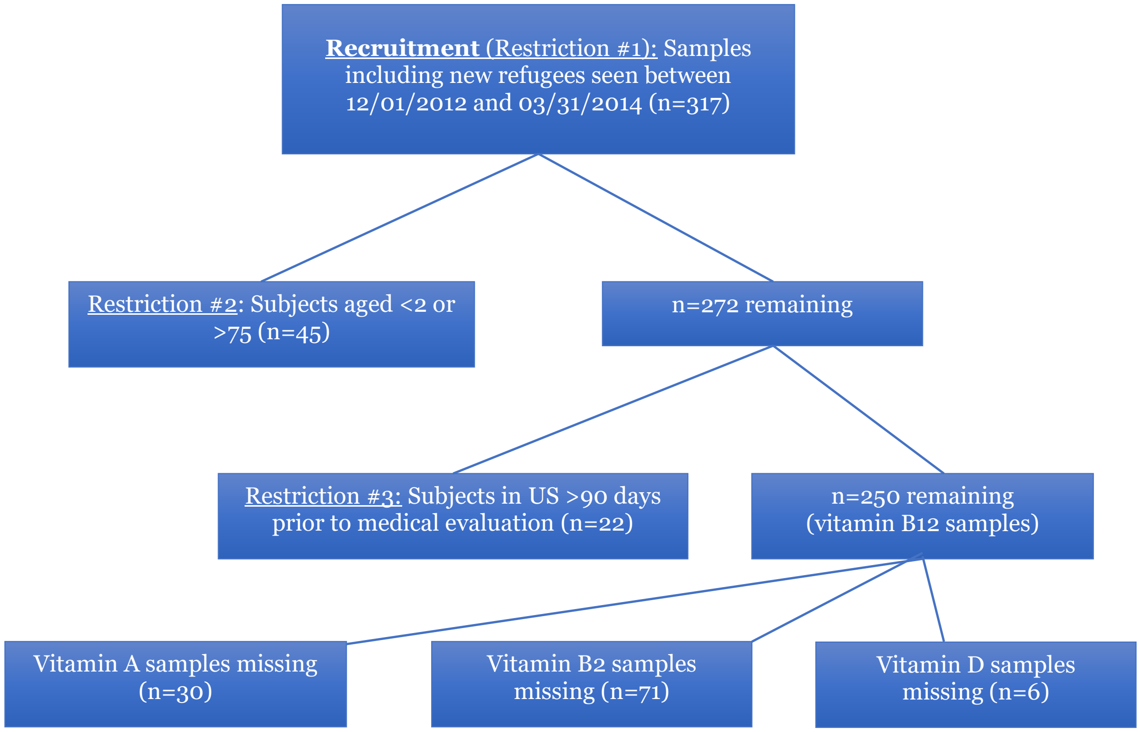

Figure 2 Participant flowchart involving sequential restriction process in identifying analytical study sample of vitamin levels.

Study Population:
250 patient charts were reviewed in this study (139 males, 111 females). Records were abstracted for 317 subjects, yet only 250 refugees met the criteria of ages between 2 and 75 years (explained below), evaluated at JRFP <90 days since resettlement, seen between December 2012 and March 2014 and successfully completed blood draws for at least two vitamin levels. In other words, 67 charts were excluded. This met our threshold criteria of 183 based upon power calculations. Moreover, because of variable phlebotomy training levels, patient/staff tolerance and laboratory errors, vitamin levels were not drawn consistently. In fact, only vitamin B12 (n=250) and D levels (n=244) were drawn from nearly all subjects. Vitamins A and B2 analyses had 220 and 179 samples, respectively. This design is schematically displayed in **Figure 2**. The study was approved by the University at Buffalo Health Sciences Institutional Review Board (IRB).

We examined the medical charts of patients from 13 countries of origin (Somalia, Sudan, DRC, Eritrea, Iraq, Iran, Jordan, Kuwait, Burma (Myanmar), Bhutan, Nepal, Thailand and Cuba). These countries of origin correspond with 17 countries of refuge (Ethiopia, Djibouti, Uganda, Kenya, Congo, Egypt, Jordan, Iraq, Turkey, Thailand, Malaysia, Nepal, Malta, Rwanda, Syria, Tunisia, and Cuba). This study focuses on vitamin deficiencies in relation to their respective country of refuge (and only indirectly in relation to their countries of origin) since we presumed that these deficiencies reflected nutritional status within these refugee camps.

Inclusion Criteria:
We restricted analyses to include only persons between the ages of 2 and 75 years. Our hypothesis was that timeframe since resettlement in the US is relevant as the longer, they have to acculturate, the less their nutritional status reflects their country of refuge. Consequently, we restricted the chart review to only include those refugees who reported having been resettled within 90 days prior to their medical evaluation.

Independent Variables:
The following independent variables were abstracted: gender (male/female), age (continuous and categorized into 2-17; 18-39 and >40 years), country of origin (categorical, one of 13 nations as noted above), country of refugee camp (categorical, one of 17 nations as reported above), length of time in US prior to medical evaluation (in days, reported by refugee agency), length of time in refugee camp (in years, as reported by International Organization of Migration).

Dependent Variables:
Routine assessment of refugees by JRFP clinical staff included laboratory panels measuring serum levels of vitamin A (serum retinol); vitamin B2 (serum riboflavin), vitamin B12 (with methylmalonic acid: MMA, as a more sensitive proxy), and vitamin D (25-OH). C-reactive protein (CRP) levels were also used to exclude subjects with an acute inflammatory phase response, which could spuriously lead to a decrease in circulating concentrations of retinol (vitamin A). Persons with CRP levels >3.10 mg/L were identified as subjects with a concurrent acute phase response and excluded from analyses of retinol level (vitamin A) only.

Vitamin deficiency levels was defined as follows:
- Vitamin A: <20 mcg/dL
- Vitamin B2: <140 ng/ml
- Vitamin B12 (MMA) >270 nmol/L
- Vitamin D (25-OH): <20 ng/ml

Data Analyses:
For the primary outcome of examining the prevalence of vitamin A, B2, B12, and D deficiencies among refugees, percentages were calculated and stratified according to age group, gender, country of origin and refuge, respectively. For the exploratory secondary objective of examining potential differences in the prevalence of vitamin deficiencies by countries of refuge, Fisher's Exact Tests

Table 1 Descriptive summary of study subjects by selected demographic variables (n=250)

Age	**M** (n=139)	**F** (n=111)	**Total**	p***
	N (%)*	**N (%)***	**N (%)****	
2-17 years	49 (57.0)	37 (43.0)	86 (34.4)	0.8802
18-39 years	62 (55.9)	49 (44.1)	111 (44.4)	
40+ years	28 (52.8)	25 (47.2)	53 (21.2)	
Total	**139 (55.6)**	**111 (44.4)**	**250**	
Country of Origin				
Somalia	16 (55.2)	13 (44.8)	29 (11.7)	0.5347
Sudan	11 (91.7)	1 (8.3)	12 (4.8)	
DRC (Democratic Republic of Congo)	7 (46.7)	8 (53.3)	15 (6.0)	
Eritrea	4(66.7)	2 (33.3)	6 (2.4)	
Iraq	12 (50.0)	12 (50.0)	24 (9.6)	
Iran	1 (100.0)	0 (0.0)	1 (0.4)	
Jordan	3 (50.0)	3 (50.0)	6 (2.4)	
Kuwait	4 (57.1)	3 (42.9)	7 (2.8)	
Myanmar (Burma)	41 (51.9)	38 (48.1)	79 (31.7)	
Bhutan	26 (54.2)	22 (45.8)	48 (19.3)	
Nepal	2 (40.0)	3 (60.0)	5 (2.0)	
Cuba	4 (80.0)	1 (20.0)	5 (2.0)	
Thailand	7 (58.3)	5 (41.7)	12 (4.8)	
Total	**138 (44.6)**	**111 (55.4)**	**249**	
Country of Refuge				
Ethiopia	8 (61.5)	5 (38.5)	13 (5.2)	0.2311
Djibouti	2 (100.0)	0 (0.0)	2 (0.8)	
Uganda	4 (36.4)	7 (63.6)	11 (4.4)	
Kenya	9 (69.2)	4 (30.8)	13 (5.2)	
Congo	1 (20.0)	4 (80.0)	5 (2.0)	
Egypt	10 (90.9)	1 (9.1)	11 (4.4)	
Jordan	8 (53.3)	7 (46.7)	15 (6.0)	
Iraq	3 (42.9)	4 (57.1)	7 (2.8)	
Turkey	6 (66.7)	3 (33.3)	9 (3.6)	
Thailand	40 (56.3)	31 (43.7)	71 (28.5)	
Malaysia	9 (40.9)	13 (59.1)	22 (8.8)	
Nepal	28 (52.8)	25 (47.2)	53 (21.3)	
Cuba	4 (80.0)	1 (20.0)	5 (2.0)	
Malta	0 (0.0)	1 (100.0)	1 (0.4)	
Rwanda	2 (66.7)	1 (33.3)	3 (1.2)	
Syria	3 (42.9)	4 (57.1)	7 (2.8)	
Tunisia	1 (100.0)	0 (0.0)	1 (0.4)	
Total	**138 (55.4)**	**111 (44.6)**	**249**	

*Calculated as row percent
**Calculated as column percent
***Based upon *Fisher's Exact Test*

Table 2 Length of time spent in refugee camps by gender, age group, country of origin, and country of refuge. (n=250)

	N	Length of Time in Camp (years)		p*
		Mean	*Median*	
Gender				
Male	81	12.6	11	0.0784
Female	50	14.8	13.5	
Age				
2-17 years	42	9.8	10.5	<0.0001
18-39 years	63	14.6	18.0	
40+ years	26	16.5	20.5	
Country of Origin				
Somalia	19	17.4	21.0	<0.0001
Sudan	11	8	8	
DRC (Democratic Republic of Congo)	5	10.6	11	
Eritrea	6	7.2	9	
Iraq	6	10.5	8	
Iran	1	6	6	
Jordan	4	11	10	
Kuwait	0	-	-	
Myanmar (Burma)	36	11.6	11	
Bhutan	34	17.6	20	
Nepal	5	11.6	10	
Cuba	2	21.5	21.5	
Thailand	2	7.0	7.0	
Country of Refuge				
Ethiopia	12	15.2	15.5	<0.0001
Djibouti	2	10	10	
Uganda	1	4	4	
Kenya	13	15.6	15	
Congo	1	14	14	
Egypt	11	8	8	
Jordan	5	10.4	9	
Iraq	1	30	30	
Turkey	2	4	4	
Thailand	27	13.5	14	
Malaysia	12	6	5	
Nepal	39	16.8	20	
Cuba	2	21.5	21.5	
Malta	0	-	-	
Rwanda	0	-	-	
Syria	3	7.7	8	
Tunisia	0	-	-	
Total	**131**	**13.4**	**11**	---

*Based upon ANOVA results

Table 3 Length of time spent in the US prior to medical evaluation by gender, age group, country of origin, and country of refuge. (n=250)

	N	Length of Time in US (days)		p*
		Mean	Median	
Gender				
Male	130	49.8	44.5	0.5761
Female	102	45.3	42	
Age				
2-17 years	74	35	33.5	0.0056
18-39 years	107	53.9	54	
40+ years	51	53.6	54	
Country of Origin				
Somalia	29	42.9	41	0.4876
Sudan	12	76.3	57	
DRC (Democratic Republic of Congo)	13	42.2	32	
Eritrea	6	53.3	39	
Iraq	24	59.1	60	
Iran	1	28	28	
Jordan	6	25.3	21	
Kuwait	6	47.7	34	
Myanmar (Burma)	74	45.2	40	
Bhutan	42	49.7	47	
Nepal	5	29.8	21	
Cuba	5	59.6	65	
Thailand	9	33.6	33	
Country of Refuge				
Ethiopia	13	51.5	39	0.3785
Djibouti	2	49.5	49.5	
Uganda	11	34.6	19	
Kenya	13	50.4	41	
Congo	3	25.3	19	
Egypt	11	77.7	54	
Jordan	14	41.9	34	
Iraq	7	66.4	68	
Turkey	9	44.8	28	
Thailand	63	41.4	40	
Malaysia	22	52.4	60	
Nepal	47	47.6	47	
Cuba	5	59.6	65	
Malta	1	55	55	
Rwanda	3	20	20	
Syria	7	61.3	55	
Tunisia	1	60	60	
Total	**232**	**47.8**	**42.5**	---

*Based upon ANOVA results

Table 4 Prevalence of vitamin A (n=220) and B2 (n=179) deficiencies, respectively, by gender, age group, country of origin, and country of internment.

	Vitamin A Deficiency		Total	p**	Vitamin B2 Deficiency		Total	p**
	Yes	No			Yes	No		
	N (%)*	N (%)*	N		N (%)*	N (%)*	N	
Gender								
Male	0 (--)	122 (100.0)	122	0.4455	5 (5.1)	94 (94.9)	99	0.2251
Female	1 (1.0)	97 (99.0)	98		1 (1.2)	80 (98.8)	81	
Total	1 (0.45)	219 (99.55)	220		6 (3.4)	173 (96.6)	179	
Age								
2-17 years	1 (1.5)	66 (98.5)	67	0.5318	2 (4.7)	41 (95.3)	43	0.7524
18-39 years	0 (--)	103 (100.0)	103		3 (3.3)	89 (96.7)	92	
40+ years	0 (--)	50 (100.0)	50		1 (2.2)	44 (97.8)	45	
Total	**1 (0.45)**	**219 (99.55)**	**220**		**6 (3.4)**	**173 (96.6)**	**179**	
Country of Origin								
Somalia	0 (--)	24 (100.0)	24	0.3744	0 (--)	20 (100.0)	20	0.8689
Sudan	0 (--)	11 (100.0)	11		0 (--)	11 (100.0)	11	
DRC (Democratic Republic of Congo)	0 (--)	14 (100.0)	14		0 (--)	13 (100.0)	13	
Eritrea	0 (--)	6 (100.0)	6		0 (--)	6 (100.0)	6	
Iraq	1 (4.4)	22 (95.6)	23		1 (7.1)	13 (92.9)	14	
Iran	0 (--)	1 (100.0)	1		0 (--)	1 (100.0)	1	
Jordan	0 (--)	6 (100.0)	6		0 (--)	6 (100.0)	6	
Kuwait	0 (--)	4 (100.0)	4		0 (--)	6 (100.0)	6	
Myanmar (Burma)	0 (--)	74 (100.0)	74		3 (6.1)	46 (93.9)	49	
Bhutan	0 (--)	39 (100.0)	39		1 (2.7)	36 (97.3)	37	
Nepal	0 (--)	3 (100.0)	3		0 (--)	3 (100.0)	3	
Cuba	0 (--)	3 (100.0)	3		0 (--)	2 (100.0)	2	
Thailand	0 (--)	11 (100.0)	11		1 (9.1)	10 (90.9)	11	
Total	**1 (0.45)**	**219 (99.55)**	**220**		**6 (3.4)**	**173 (96.6)**	**179**	
Country of Refuge								
Ethiopia	0 (--)	11 (100.0)	11	0.2009	0 (--)	10 (100.0)	10	0.7672
Djibouti	0 (--)	1 (100.0)	1		0 (--)	1 (100.0)	1	
Uganda	0 (--)	9 (100.0)	9		0 (--)	10 (100.0)	10	
Kenya	0 (--)	13 (100.0)	13		0 (--)	8 (100.0)	8	
Congo	0 (--)	4 (100.0)	4		0 (--)	4 (100.0)	4	
Egypt	0 (--)	10 (100.0)	10		0 (--)	10 (100.0)	10	
Jordan	0 (--)	12 (100.0)	12		0 (--)	13 (100.0)	13	
Iraq	0 (--)	6 (100.0)	6		0 (--)	3 (100.0)	3	
Turkey	1 (11.1)	8 (88.9)	9		1 (20.0)	4 (80.0)	5	
Thailand	0 (--)	68 (100.0)	68		4 (8.0)	46 (92.0)	50	
Malaysia	0 (--)	19 (100.0)	19		0 (--)	12 (100.0)	12	
Nepal	0 (--)	42 (100.0)	42		1 (2.5)	39 (97.5)	40	
Cuba	0 (--)	3 (100.0)	3		0 (--)	2 (100.0)	2	
Malta	0 (--)	1 (100.0)	1		0 (--)	1 (100.0)	1	
Rwanda	0 (--)	3 (100.0)	3		0 (--)	3 (100.0)	3	
Syria	0 (--)	7 (100.0)	7		0 (--)	6 (100.0)	6	
Tunisia	0 (--)	1 (100.0)	1		0 (--)	1 (100.0)	1	
Total	**1 (0.45)**	**219 (99.55)**	**220**		**6 (3.4)**	**173 (96.6)**	**179**	

*Calculated as row percent
**Based upon *Fisher's Exact Test*

Table 5 Prevalence of vitamin B12 (n=250) and D (n=243) deficiencies, respectively, by gender, age group, country of origin, and country of refuge.

	Vitamin B12 Deficiency		Total	p**	Vitamin D Deficiency		Total	p**
	Yes	No			Yes	No		
	N (%)*	N (%)*	N		N (%)*	N (%)*	N	
Gender								
Male	59 (42.5)	80 (57.5)	139	0.0654	67 (48.2)	70 (51.8)	137	<0.0001
Female	34 (30.6)	77 (69.4)	111		76 (71.0)	31 (29.0)	107	
Total	**93 (37.2)**	**157 (62.8)**	**250**		**143 (58.9)**	**100 (41.1)**	**243**	
Age								
2-17 years	34 (39.5)	52 (60.5)	86	0.8738	48 (57.1)	36 (42.9)	84	0.4965
18-39 years	40 (36.0)	71 (64.0)	111		68 (62.4)	41 (37.6)	109	
40+ years	19 (35.9)	34 (64.1)	53		27 (52.9)	24 (47.1)	51	
Total	**93 (37.2)**	**157 (62.8)**	**250**		**143 (58.9)**	**100 (41.1)**	**243**	
Country of Origin								
Somalia	7 (24.1)	22 (75.9)	29	<0.0001	22 (78.6)	6 (21.4)	28	0.0006
Sudan	11 (91.7)	1 (8.3)	12		10 (90.9)	1 (9.1)	11	
DRC (Democratic Republic of Congo)	1 (6.7)	14 (93.3)	15		3 (20.0)	12 (80.0)	15	
Eritrea	3 (50.0)	3 (50.0)	6		4 (66.7)	2 (33.3)	6	
Iraq	9 (37.5)	15 (62.5)	24		14 (63.6)	8 (36.4)	22	
Iran	0 (--)	1 (100.0)	1		1 (100.0)	0 (--)	1	
Jordan	4 (66.7)	2 (33.3)	6		5 (83.3)	1 (16.7)	6	
Kuwait	4 (57.1)	3 (42.9)	7		6 (100.0)	0 (00.0)	6	
Myanmar (Burma)	19 (24.1)	60 (75.9)	79		40 (51.3)	38 (48.7)	78	
Bhutan	29 (60.4)	19 (39.6)	48		27 (56.3)	21 (43.8)	48	
Nepal	2 (40.0)	3 (60.0)	5		4 (80.0)	1 (20.0)	5	
Cuba	1 (20.0)	4 (80.0)	5		1 (20.0)	4 (80.0)	5	
Thailand	3 (25.0)	9 (75.0)	12		6 (50.0)	6 (50.0)	12	
Total	**93 (37.2)**	**157 (62.8)**	**250**		**143 (58.9)**	**100 (41.1)**	**243**	
Country of Refuge								
Ethiopia	3 (23.1)	10 (76.9)	13	<0.0001	10 (76.9)	3 (23.1)	13	0.0002
Djibouti	0 (--)	2 (100.0)	2		0 (--)	2 (100.0)	2	
Uganda	0 (--)	11 (100.0)	11		5 (50.0)	6 (50.0)	10	
Kenya	7 (53.9)	6 (46.1)	13		11 (84.6)	2 (15.4)	13	
Congo	0 (--)	5 (100.0)	5		0 (--)	5 (100.0)	5	
Egypt	11 (100.0)	0 (--)	11		10 (100.0)	0 (00.0)	10	
Jordan	9 (60.0)	6 (40.0)	15		12 (85.7)	2 (14.3)	14	
Iraq	2 (28.6)	5 (71.4)	7		4 (66.7)	2 (33.3)	6	
Turkey	3 (33.3)	6 (67.7)	9		6 (66.7)	3 (33.3)	9	
Thailand	18 (25.4)	53 (74.6)	71		32 (45.1)	39 (54.9)	71	
Malaysia	4 (18.2)	18 (81.8)	22		16 (76.2)	5 (23.8)	21	
Nepal	31 (58.5)	22 (41.5)	53		31 (58.5)	22 (41.5)	53	
Cuba	1 (20.0)	4 (80.0)	5		1 (20.0)	4 (80.0)	5	
Malta	0 (--)	1 (100.0)	1		1 (100.0)	0 (--)	1	
Rwanda	1 (33.3)	2 (66.7)	3		0 (--)	3 (100.0)	3	
Syria	3 (42.9)	4 (57.1)	7		4 (66.7)	2 (33.3)	6	
Tunisia	0 (--)	1 (100.0)	1		0 (--)	1 (100.0)	1	
Total	**93 (37.2)**	**157 (62.8)**	**250**		**143 (58.9)**	**100 (41.1)**	**243**	

*Calculated as row percent

**Based upon *Fisher's Exact Test*

were run in order to examine the significance in differences between prevalence of vitamin deficiencies among the refugee populations – according to countries of origin and refuge, respectively. This was also run for covariates (age and gender) as well. Numbers and relative percentages of specific vitamin deficiencies were summarized.

We further analyzed length of time spent in refugee camps as well as time spent in US prior to evaluation. The former was used as an independent variable, as it was hypothesized that length of time spent in refugee camp was a predictor for deficiency. The latter was used to exclude certain subjects that were present in the US >90 days, as that might bias interpretation. Both of these measures were further analyzed using ANOVA to explore which variables could explain the variability of results.

Results

Demographics:
As presented in **Table 1**, the most populous age group were those 18-39 years (44.4%, p=0.88). Fisher's Exact Test revealed that there were also no significant differences by age according to gender (p=0.88). Males represented 55.6% of this sample, which was consistent throughout all age cohorts. Thirteen countries of origin were represented in our sample without any significant difference between gender (p=0.53). Myanmar (Burma) and Bhutan were the most represented countries of origin at 31.7% and 19.3% of the sample, respectively. East African nations were the next largest group in our sample – with Somalis representing 11.7% and Congolese representing 6.0%. In terms of countries of refuge, Thailand accounted for the largest group of refugees (Burmese) at 28.5% followed by Nepal (21.3%) and Malaysia (8.8%), Kenya (5.2%) and Ethiopia (5.2%). Again, Fisher's Exact Test revealed there were no significant difference in gender by countries of origin (p=0.54) and refuge (p=0.23).

Time spent in refugee camps and time in US prior to medical evaluation:
As presented in **Table 2**, the mean length of time spent in refugee camps was 13.4 years and ranged anywhere from 4.0 in Turkey and Uganda to 17.6 years in Kenya. Based upon ANOVA analysis, most variables can explain a significant portion of the variance in time spent in refugee camps – including age, country of origin and refuge (p<0.0001), with gender approaching significance (p=0.08).

After excluding 12 charts because of the extended duration of time in the US prior to medical evaluation (>90 days), the mean duration of time in the US prior to medical evaluation was 47.8 days and ranged from 20.0 days among those held in Rwanda to 77.0 days for those in camps in Egypt, as reported in **Table 3**. Based upon ANOVA analysis, age was the only variable that could significantly (p=0.006) explain variance in length of time spent in the US prior to medical evaluation, given the other variables in the model.

Prevalence of vitamin deficiencies:
Prevalence of vitamin deficiencies are reported in **Tables 4 and 5**. There was only one deficient vitamin A sample (1/220, 0.45%, p=0.20). As **Table 4** demonstrates, only 6 subjects (3.4%) were noted to have deficient vitamin B2 levels. There were no significant difference between prevalence of deficiency across countries of origin (p=0.87), refuge (p=0.77), age category (p=0.75), or gender (p=0.23).

Overall, 37.2% of refugees (93/249) were vitamin B12 deficient, based upon MMA measurements. Differences across countries of origin (p<0.0001) and refuge (p<0.0001), were highly significant, and approached significance for gender (p=0.07), but were not significant for age category (p=0.87). It is worth note that the Djibouti, Uganda, Congo, Malta and Tunisia all had 0% deficiency.

As presented in **Table 5**, 58.6% of refugees were considered vitamin D deficient (143/244). The prevalence of vitamin D deficiency significantly differed by country of origin (p=0.0006), refuge (p=0.0002), and gender (p<0.0001). However, there were no significant differences based upon age category (p=0.50). It is worth note that those who were held in Egyptian refugee camps (i.e., Sudanese) demonstrated 100.0% and 90.1% vitamin B12 and D deficiencies, respectively. Nepal (Vitamin D: 58.5%; vitamin B12: 58.5%) and Jordan (Vitamin D: 85.7%; vitamin B12: 60.0%) also demonstrated similarly high prevalence of deficiency in both vitamins B12 and D. Finally, Burmese subjects living in Malaysian refugee camps demonstrated 76.2% vitamin D deficiency; whereas Burmese in neighboring Thai refugee camps showed 45.1% deficiency.

Discussion

Most germane to this study was the overall prevalence of micronutrient deficiency levels among this convenience sample of refugees. There was only one case of vitamin A deficiency. This appears to reflect the success of current public health efforts of fortifying vitamin A in food aid. Curiously, while those residing in Cuba never actually spent any time in refugee camps (as they were directly resettled from Cuba to the USA, and therefore did not receive any food aid), they had the lowest mean vitamin A levels (30.5 mcg/dl).

In terms of vitamin B2 deficiency, only 6 of the 180 subjects tested lower than the level defined as normal. This is in contrast to the study by Blanck et al (9), which found that 86% of the Bhutanese were B2 deficient. In fact, only 1 out of the 40 Bhutanese held in Nepal were deficient. It is noteworthy that vitamin B2 is not fortified in any food aid. (3)

Levels of vitamin B12 and D were more commonly deficient among these subjects. Prevalence of vitamin B12 deficiency was higher than expected (37.2%), as it was only exceeded by one other study in the literature focusing exclusively on Bhutanese refugees. (10) Curiously, the Bhutanese represented a large percentage of our sample (48/250, 19.2%). Further, it is noteworthy that prevalence of B12 deficiency was quite different in Ethiopia (23.1%) than in Kenya (53.9%), despite the fact that they mostly accommodated Somalis. It is further noteworthy that Djibouti and Congo both demonstrated 0.0% prevalence of deficiency of both vitamin B12 and D, considering mechanisms are distinct. Moreover, both Thailand (25.4%) and Malaysia (18.2%) had a lower than average prevalence of B12 deficiency. This was surprising because of similar cultural practices with the Bhutanese. In fact, the latter tend to eat more meat as they are mostly of Hindu faith – whereas many of the Burmese identify as Buddhist (and are classically vegetarian). (19)

As **Table 1** describes, the majority of our patients were males between the ages of 18 and 39 years and generally held in camps in either East Asia or East Africa. Indeed, 10.4% of the patients were held in Kenya (n=13) and Ethiopia (n=13); with 37.2% held in Thailand (n=71) and Malaysia (Burmese) (n=22); and 21.2% held in Nepal (n=53).

Information on length of time spent both in their respective refugee camps as well as post-resettlement duration in the US was relevant in terms of identifying the etiology of micronutrient deficiency as well as corrective measures to address those potential deficiencies. The average amount of time spent in those refugee camps was 13.4 years (range 6-17 years). Those held in East Africa (i.e. Kenya at 15.6 years and Ethiopia at 15.2 years) as well as those in Nepal (16.8 years) were held there the longest, by far. It appears that all refugees spent a sufficient amount of time in refugee camps to develop vitamin deficiencies plausibly reflected in the diet provided at those camps.

Our study reviewed medical charts among refugees who presented for care between January and March, but benefitted from a short mean duration of resettlement (47.8 days) and an eligibility restriction of <90 days in the US. Consequently, assuming that nutrition practices had not changed dramatically, this short duration likely did not correct certain deficiencies that may have been precipitated by refugee camp dietary practices. It appears reasonable to infer from this limited duration in the US, that any deficiencies encountered were unlikely to be a product of their time spent in the US post-resettlement. (20)

Our findings of the Bhutanese (60.4%) were consistent with B12 levels reported by those resettled in Minnesota (27.0%) and Australia (31.1%). (9, 10) It is possible that our prevalence estimate could be higher as a result of the use of MMA, which is a more sensitive biomarker for the early detection of functional vitamin B12 deficiency. Other studies have argued for the use of MMA as a proxy for vitamin B12 (11) but many of them were practically constrained secondary to prohibitive costs. (11) Notwithstanding this challenge, we actually found direct MMA to be much less expensive than direct B12 measurement, and much more practical (and effective) in the long run, as it has less sensitive laboratory requirements. Most (if not all) patients were asymptomatic, as had been demonstrated in a prior study. (11) However, it was difficult for us to explore the correlation of symptoms with vitamin deficiencies, as we were limited by a retrospective chart review.

Almost all countries of refuge demonstrated substantial vitamin D deficiency (as presented in **Table 5**). Females had higher proportions of deficiency, on average – 71.0% vs. 48.2%. This is to be expected based upon occupational and cultural practices. (18) Surprisingly, those between the ages of 18-39 had the highest proportion of deficiency (62.4%), as it would be expected this group would represent the most employable, and thereby those with most sun exposure. However, constraints in refugee camps may limit such typical practices. Curiously, Malaysia had a much higher prevalence of vitamin D deficiency (76.2%) than Thailand (45.1%; p<0.0001) despite the fact that camps are populated by refugees from the same country of origin (Burmese) and both exhibit strikingly similar climates.

It is noteworthy that all refugee camps holding those originally from Middle Eastern/North African countries (i.e., Egypt, Jordan, Iraq, and Turkey) had the highest proportions of D deficiency. Such lower vitamin D levels seem to be attributable to sunlight restrictions seen prominently in followers of Islam (namely women). (15, 17, 18) Gender was highly significant in detecting differences (p<0.001) in prevalence of vitamin D deficiency. Considering many of these women are of Islamic faith, it is likely that many of these women remain covered, and therefore unexposed to the sun. (18) This is further compounded by dark skin pigmentation among these populations. Finally, these countries (e.g., Somalia and DRC) are heavily entrenched in conflict, which could certainly explain the need to hide (and the associated post-traumatic stress that precipitates future avoidance behaviors). (14)

Conversely, those interned in Congo, Djibouti and Cuba were all protected. This was not expected considering the dark skin pigmentation found in refugees frequenting these camps. Such differences between North Africans/Middle Easterners and Sub-Saharan Africans seem to reflect the importance of cultural differences playing a paramount role over physical differences.

In conclusion, this study demonstrated a very low prevalence of deficiency in vitamins A and B2. In contrast, prevalence of vitamin B12 deficiency was much higher than anticipated and vitamin D deficiency was consistent with expectations. This wide variance in prevalence between vitamin groups reflects the relative success and failures of current public health nutritional practices. This should prompt a call to action not only for the international nutritional forum advising on guidelines for micronutrient supplementation in high risk groups, but also for US-based public health agencies (particularly in NY state), departments of health, community health centers, and refugee resettlement agencies to focus on such public health issues following resettlement. Hopefully, improvement in the detection and management of such micronutrient deficiencies will have very practical implications for the future resettlement of refugees in the US.

Limitations

Some potential limitations have been identified and should be discussed. First, while the time span of 30-90 days in the US is likely insufficient to restore vitamin levels, it is not impossible, which may mask possible previous deficiencies while living in respective refugee camps. Second, we encountered limitations in drawing blood specimens from children, handling specimens (e.g., vitamin B2 specimen is photosensitive), and implementing our protocol into practice at JRFP. As a result, numbers were limited for both vitamins A (n=220) and B2 (n=179) relative to the entire sample size of 250. Admittedly, this further limits our analysis and biases our results by systematically excluding younger children.

Third, discrepancies are frequently found in the literature in terms of defined levels of deficiency across international studies. Depending on respective international guidelines, these defined levels of vitamin D deficiency range from 10 ng/ml (25.0 nmol/L) to 30 ng/ml (74.9 nmol/L). (21, 22) We defined our level of deficiency by guidelines written by the Institute of Medicine (20 ng/ml). (22) Therefore, it is difficult to directly compare the results of such studies. Fourth, as this was a convenience sample, the data cannot be generalized to all refugees residing in camps worldwide, but can hopefully generate more interest in designing additional studies to assess more refugee populations across the global spectrum.

Fifth, there may have been diurnal variation in many of these physiological biomarkers. And while the biomarkers of vitamin levels analyzed have been deemed the gold standard, there are certain inherent flaws in both sensitivity and specificity when defining vitamin deficiency. Sixth, other abnormalities may bias results. Examples are inflammation and serum retinol as well as abnormal renal function and MMA. We attempted to correct for this as much as possible (e.g. collection of CRP).

Seventh, low vitamin levels may actually be a consequence of situational factors (e.g. conflict, food insecurity) in their respective countries of origin prior to refugee status. Eighth, cultural dietary habits (e.g. vegetarian, halal) may confound the relationship between poor fortification in food aid at refugee camps and low vitamin levels. Finally, we did not collect clinical examination findings, as we felt this information had little utility (based upon previous studies) in assessing all stages of deficiency (particularly early stages). Consequently, we did not report any findings that may have been useful in qualitatively describing how certain groups may have been more clinically affected than others.

Compliance with Ethical Standards

- There are no reportable conflicts. This study was exclusively self-funded by the department of Epidemiology and Environmental Health, SUNY at Buffalo.
- All research conducted was done so retrospectively consistent with quality improvement.
- Informed consent was neither required nor taken.

References

1. Wilson JA. Vitamin deficiency and excess. In: Fauci AS, Braunwald E, Isselbacher K, editors. Harrison's Principles of Internal Medicine, 14th. New York: McGraw-Hill; 1998. p. 481.
2. Weise Prinzo Z, de Benoist B. Meeting the challenges of micronutrient deficiencies in emergency-affected populations. Proc Nutr Soc. 2002 May;61(2):251–7. https://doi.org/10.1079/PNS2002151 PMID:12133207
3. WHO/World Food Programme/United Nations Children's Fund (UNICEF). Preventing and controlling micronutrient deficiencies in populations affected by an emergency. Multiple vitamin and mineral supplements for pregnant and lactating women, and for children aged 6 to 59 months. Geneva: WHO/WFP/UNICEF; 2007.
4. Worldwide Refugee Admissions Processing System (WRAPS). RPC/rpt_WebArrivalsReports/Map - Arrivals by State and Nationality Report Run Date: 4/22/2019 1:54:56 PM
5. Jericho Road Ministries (JRM). Our History. http://www.jrm-buffalo.org/About/History.aspx. Accessed on November 22, 2012.
6. Imdad A, Herzer K, Mayo-Wilson E, Yakoob MY, Bhutta ZA. Vitamin A supplementation for preventing morbidity and mortality in children from 6 months to 5 years of age. Cochrane Database Syst Rev. 2010 Dec;12(12):CD008524. https://doi.org/10.1002/14651858.CD008524.pub2 PMID:21154399
7. Seal AJ, Creeke PI, Mirghani Z, Abdalla F, McBurney RP, Pratt LS, et al. Iron and vitamin A deficiency in long-term African refugees. J Nutr. 2005 Apr;135(4):808–13. https://doi.org/10.1093/jn/135.4.808 PMID:15795439
8. Woodruff BA, Blanck HM, Slutsker L, Cookson ST, Larson MK, Duffield A, et al. Anaemia, iron status and vitamin A deficiency among adolescent refugees in Kenya and Nepal. Public Health Nutr. 2006 Feb;9(1):26–34. https://doi.org/10.1079/PHN2005825 PMID:16480530
9. Blanck HM, Bowman BA, Serdula MK, Khan LK, Kohn W, Woodruff BA; Bhutanese Refugee Investigation Group. Angular stomatitis and riboflavin status among adolescent Bhutanese refugees living in southeastern Nepal. Am J Clin Nutr. 2002 Aug;76(2):430–5. https://doi.org/10.1093/ajcn/76.2.430 PMID:12145018
10. Walker PF, et al.; Centers for Disease Control and Prevention (CDC). Vitamin B12 deficiency in resettled Bhutanese refugees—united States, 2008-2011. MMWR Morb Mortal Wkly Rep. 2011 Mar;60(11):343–6. PMID:21430638
11. Benson J, Phillips C, Kay M, Webber MT, Ratcliff AJ, Correa-Velez I, et al. Low vitamin B12 levels among newly-arrived refugees from Bhutan, Iran and Afghanistan: a multicentre Australian study. PLoS One. 2013;8(2):e57998. https://doi.org/10.1371/journal.pone.0057998PMID:23469126
12. Allen RH, Stabler SP, Savage DG, Lindenbaum J. Metabolic abnormalities in cobalamin (vitamin B12) and folate deficiency. FASEB J. 1993 Nov;7(14):1344–53. https://doi.org/10.1096/fasebj.7.14.7901104 PMID:7901104
13. Sumner AE, Chin MM, Abrahm JL, Berry GT, Gracely EJ, Allen RH, et al. Elevated methylmalonic acid and total homocysteine levels show high prevalence of vitamin B12 deficiency after gastric surgery. Ann Intern Med. 1996 Mar;124(5):469–76. https://doi.org/10.7326/0003-4819-124-5-199603010-00002 PMID:8602704
14. Sheikh M, Wang S, Pal A, MacIntyre CR, Wood N, Gunesekera H. Vitamin D deficiency in refugee children from conflict zones. J Immigr Minor Health. 2011 Feb;13(1):87–93. https://doi.org/10.1007/s10903-010-9325-9 PMID:20198433
15. Wishart HD, Reeve AM, Grant CC. Vitamin D deficiency in a multinational refugee population. Intern Med J. 2007 Dec;37(12):792–7. https://doi.org/10.1111/j.1445-5994.2007.01385.x PMID:17517080
16. McGillivray G, Skull SA, Davie G, Kofoed SE, Frydenberg A, Rice J, et al. High prevalence of asymptomatic vitamin D and iron deficiency in East African immigrant children and adolescents living in a temperate climate. Arch Dis Child. 2007 Dec;92(12):1088–93. https://doi.org/10.1136/adc.2006.112813 PMID:17768148
17. Aucoin M, Weaver R, Thomas R, Jones L. Vitamin D status of refugees arriving in Canada: findings from the Calgary Refugee Health Program. Can Fam Physician. 2013 Apr;59(4):e188–94. PMID:23585622
18. Grover SR, Morley R. Vitamin D deficiency in veiled or dark-skinned pregnant women. Med J Aust. 2001 Sep;175(5):251–2. PMID:11587255
19. BRYCS. Refugee 101 Retrieved November 20, 2012, from http://www.brycs.org/aboutRefugees/refugee101.cfm
20. Toole MJ. Micronutrient deficiencies in refugees. Lancet. 1992 May;339(8803):1214–6. https://doi.org/10.1016/0140-6736(92)91143-V PMID:1349947
21. Forrest KY, Stuhldreher WL. Prevalence and correlates of vitamin D deficiency in US adults. Nutr Res. 2011 Jan;31(1):48–54. https://doi.org/10.1016/j.nutres.2010.12.001PMID:21310306
22. Hollis BW, Wagner CL. Normal serum vitamin D levels. N Engl J Med. 2005 Feb;352(5):515–6. https://doi.org/10.1056/NEJM200502033520521 PMID:15689596