Adjustment for Altitude

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Haemoglobin concentrations vary with a variety of factors namely with age, sex and stage of pregnancy. They are also affected by ethnicity, altitude and smoking. It is because of this reason that there are different cut offs of anaemia depending on the age and sex. Many pregnant women in refugee setting might not accurately know their gestational age and it is due to this reason as well as the small sample size that testing haemoglobin in pregnant women is now excluded in nutrition surveys conducted in refugee contexts.

At 1000m above sea level, haemoglobin concentration is known to increase to compensate for the lowered partial pressure of oxygen and reduced oxygen saturation of blood. This results into a compensatory increased production of red blood cells that enables sufficient supply of oxygen to the tissues[1]. The progression is curvilinear, with the increase in haemoglobin concentration becoming steeper as altitude increases.

Two publications provide information on haemoglobin cut off values and adjustments (UNICEF, UNU, WHO 2001; Nestel & The INACG Steering Committee 2002). Although the difference between the two publications are minor, according to Sullivan et al from the Centers for Disease Control and Prevention, the UNICEF, UNU, WHO 2001 guidance is preferred due to the consensus by a number of experts.

The adjustment for altitude is based on the following formula.

$$\text{Hb adjustment} = -0.032 \times (\text{altitude in metres} \times 0.0032808) + 0.022 \times (\text{altitude in metres} \times 0.0032808)^2$$

Haemoglobin adjustment can be done in two ways. It can be done by adjusting the haemoglobin cut-offs by adding an adjustment factor to the cut-off itself and then the adjusted cut-off is compared to the non-adjusted individual haemoglobin value of the persons being tested (herein referred to as method 1). Or the adjustment factor can be subtracted from the individual haemoglobin concentrations and then compared with the normal or non-adjusted cut-offs used routinely (herein referred to as method 2).

The table below gives the cut-off adjustment (method 1) as well as the adjusted individual haemoglobin based on different altitude levels (method 2). In this table the altitudes have been grouped and hence it provides an estimated adjustment of the haemoglobin levels based on the categories of altitude.

[1] Centers for Disease Control and Prevention. Criteria for anemia in children and childbearing-aged women. MMWR Morb Mortal Wkly Rep 1989;38:400–404

Table 1 Adjustments to haemoglobin cut offs and individual haemoglobin values for altitude[2]

	Method 1	Method 2
Altitude (m)	**Adjustment to haemoglobin cut-off value (g／dl)**	**Adjustment to individual haemoglobin value (g／dl)**
<1000	No adjustment	No adjustment
≥1000, <1250	+0.2	-0.2
≥1250,<1750	+0.5	-0.5
≥1750, <2250	+0.8	-0.8
≥2250, <2750	+1.3	-1.3
≥2750, <3250	+1.9	-1.9
≥3250, <3750	+2.7	-2.7
≥3750, <4250	+3.5	-3.5
≥4250, <4750	+4.5	-4.5
≥4750, <5250	+5.5	-5.5
≥5250	+6.7	-6.7

UNHCR recommends that **method 2** be used in all settings where haemoglobin needs to be adjusted for altitude in a SENS Nutrition Survey. The below table provides the specific adjustment factor to be applied to each individual haemoglobin values for refugee camps/situations where haemoglobin needs to be adjusted for altitude in a SENS Nutrition Survey. The camp/situation elevation data was obtained from UNHCR GIS department (2012) and camps/situations with an altitude above 1000m are listed below.

[2] Kevin M. Sullivan, Zuguo Mei, Laurence Grummer-Strawn, and Ibrahim Parvanta, (2008) Haemoglobin adjustments to define anaemia. Tropical Medicine and International volume 13 no 10 pp 1267–1271

Individual Haemoglobin Adjustment for SENS Nutrition Surveys

Country	Camp / Situation	Elevation (in feet)	Elevation (in metres)	Reduction in individual HB concentration (g/dl)
Burundi	Butare	5039	1535.89	-0.4
Burundi	Bwagiriza	5092	1552.04	-0.4
Burundi	Gasorwe/ Kinama	5621	1713.28	-0.5
Burundi	Musasa	5790	1764.80	-0.6
Ethiopia	Shimelba	3404	1037.54	-0.1
Ethiopia	Sherkole	4086	1245.42	-0.2
Ethiopia	Adi Harush	4336	1321.62	-0.3
Ethiopia	My Ayni	4593	1399.95	-0.3
Ethiopia	Awbarre	5321	1621.84	-0.5
Ethiopia	Kebribeyah	5583	1701.70	-0.5
Ethiopia	Sheder	5649	1721.82	-0.5
Islamic Republic of Iran	Saveh	3314	1010.11	-0.1
Islamic Republic of Iran	Jahrom	3327	1014.07	-0.1
Islamic Republic of Iran	Semnan	3735	1138.43	-0.2
Islamic Republic of Iran	Soltanieh	3819	1164.03	-0.2
Islamic Republic of Iran	Dizli	4630	1411.23	-0.3
Islamic Republic of Iran	Kangavar	4925	1501.14	-0.4
Islamic Republic of Iran	Rafsanjan	4937	1504.80	-0.4
Islamic Republic of Iran	Bazileh	4973	1515.77	-0.4
Islamic Republic of Iran	Songhor	5511	1679.76	-0.5
Islamic Republic of Iran	Ziveh	5679	1730.96	-0.5
Islamic Republic of Iran	Varmahang	5846	1781.86	-0.6
Islamic Republic of Iran	Azna	6084	1854.41	-0.6
Islamic Republic of Iran	Bardsir	6884	2098.25	-0.8
Islamic Republic of Iran	Dilzeh	7715	2351.54	-1.1
Malawi	Dzaleka	4808	1465.48	-0.4
Namibia	Osire	4444	1354.53	-0.3
Rwanda	Nyabiheke	5289	1612.09	-0.4
Rwanda	Kiziba	6478	1974.50	-0.7
Rwanda	Gihembe	7463	2274.73	-1.0
Thailand	Umpium	3962	1207.62	-0.2
United Republic of Tanzania	Nyarugusu	4000	1219.20	-0.2
United Republic of Tanzania	Mtabila I	4385	1336.55	-0.3
United Republic of Tanzania	Kanembwa	4525	1379.22	-0.3
Zambia	Kala	4365	1330.45	-0.3
Zambia	Mwange	4650	1417.32	-0.3