

Adjustment for altitude¹

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 in a compensatory increased production of red blood cells that enables sufficient supply of oxygen to the tissues². 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 Original version of the document developed in 2012 by Ismail Arte Raga (former UNHCR Regional Support Hub Nairobi) and Méloody Tondeur (UNHCR Nutrition Consultant) based on experience in conducting nutrition surveys in Rwanda.

2 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 altitude³

	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 (2018) and camps/situations with an altitude above 1000m are listed below.

Note that these altitude adjustments can be automatically done in mobile data collection (MDC) SENS surveys at the data collection stage so that the survey manager does not need to do any conversion at the analysis stage.

³ 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

Table 2 Individual Haemoglobin Adjustments for SENS Nutrition Surveys

Country	Camp / Situation	Elevation (in feet)	Elevation (in metres)	Reduction in individual HB concentration (g/dl)
Afghanistan	Gulan	4247	1294.51	-0.2
Burundi	Gasorwe / Kinama	5626	1714.74	-0.5
Burundi	Kavumu	5452	1661.88	-0.5
Burundi	Musasa	5769	1758.36	-0.6
Burundi	Bwagiriza	5094	1552.78	-0.4
Ethiopia	Sherkole	4099	1249.40	-0.2
Ethiopia	Sheder	5648	1721.58	-0.5
Ethiopia	Tongo	5913	1802.25	-0.6
Ethiopia	Bambasi	4677	1425.61	-0.3
Ethiopia	Tsore	5094	1552.63	-0.4
Ethiopia	Mai Aini	5224	1592.14	-0.4
Ethiopia	Kebribeyah	5688	1733.81	-0.5
Ethiopia	Aw-barre	5287	1611.45	-0.5
Ethiopia	Adi Harush	4409	1343.78	-0.3
Ethiopia	Shimelba	3374	1028.29	-0.1
Ethiopia	Hitsats	3477	1059.81	-0.1
Ethiopia	Gure-Shombola	4649	1417.11	-0.3
Malawi	Dzaleka	4810	1465.98	-0.4
Rwanda	Kigeme	7050	2148.71	-0.8
Rwanda	Gihembe	7443	2268.63	-1.0
Rwanda	Kiziba	6496	1979.90	-0.7
Rwanda	Nyabiheke	5291	1612.84	-0.4
Rwanda	Mugombwa	5330	1624.71	-0.5
Rwanda	Mahama	4430	1350.24	-0.3
Thailand	Umpiem	3929	1197.55	-0.2
United Republic of Tanzania	Nduta	4302	1311.38	-0.3
United Republic of Tanzania	Mtendeli	4284	1305.70	-0.3
United Republic of Tanzania	Nyarugusu	4014	1223.46	-0.2